AUTOMOBILE ENGINEER

DESIGN · PRODUCTION · MATERIALS

Vol. 46 No. 4 APRIL 1956 PRICE: 3s. 6d.

Cold impact extrusion

... the fastest metal-forming technique

Cold impact extrusion is a fast and economical method of producing hollow containers and complex shapes in non-ferrous and certain ferrous materials.

Save cost and material

Many components now used in industry and produced by a variety of other processes, lend themselves to production by impact extrusion with consequent saving in cost and material. This cold forming process induces added strength in parts by utilising the grain flow, and produces a smooth and flawless finish.

For mass-production

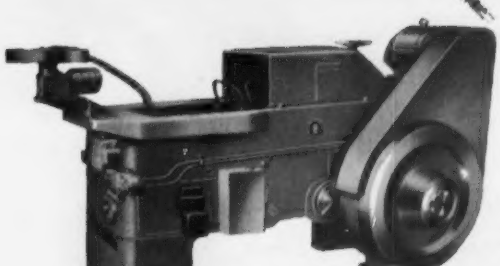
Herlan presses mass-produce accurate extrusions, and machines are available with production rating from 35 to 95 parts a minute. Extrusions up to 4¾″ diameter (aluminium) at a wall thickness of 0·011″ and maximum length of 12¾″ may be obtained from these versatile machines.

Automatic operation

The presses are entirely automatic, and after loading, feed, form, strip-off and eject in rapid sequence. The horizontal working stroke is absolutely smooth and bottom thickness can be adjusted while the press is in motion. Shockless operation promotes long tool life and provision for rapid tool change provides maximum flexibility.

HERLAN

EXTRUSION PRESSES



Type P3 which produces up to 90 parts a minute.

INTERNATIONAL MACHINE TOOL EXHIBITION 1956
June 22–July 6
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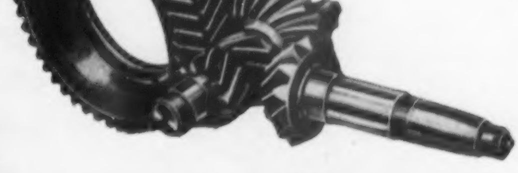
THROUGHOUT THE WORLD, on passenger and commercial vehicles, DAVID BROWN automobile transmission components are giving dependable service. For rear-axle drives—worm gears, spiral or hypoid bevel gears—for timing, magneto, oil pump and speedometer drives—for gear-box, steering, starter and clutch gears, and power take-off drives from the main gear-box—in fact, whatever the drive, the DAVID BROWN organisation can supply your needs with components backed by the soundness and reliability associated with DAVID BROWN.



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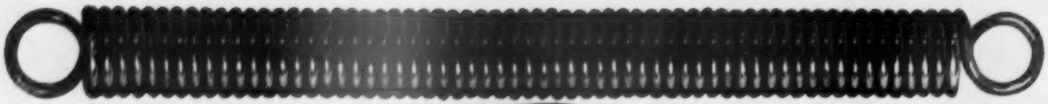
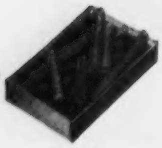
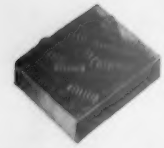
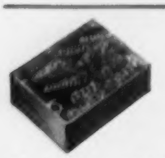




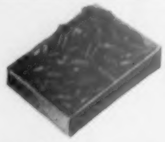
No. 760. 3 doz. Assorted Light Compression Springs 1" to 4" long, 22 to 18 S.W.G., ⅜" to ½" diam. 6/6 each.



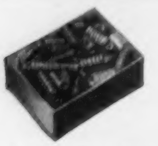
No. 98A. 3 doz. Assorted 1" to 4" long, ⅜" to ⅝" diam., 19G to 15G. 5/6 each.



No. 757. Extra Light Compression, 1 gross assorted, ⅛" to ⅜", ¼" to 2" long, 27 to 20 S.W.G. 15/- each.

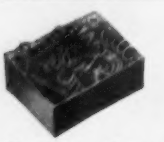


No. 388. ½ gross Assorted Small Expansion Springs. ⅜" to 1½", 18G to 21G. 9/6 each.

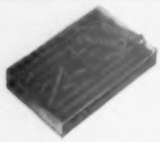


No. 758. Fine Expansion Springs. 1 gross Assorted ⅛" to ⅜", ½" to 2" long, 27 to 20 S.W.G. 15/- each.

No. 466. ½ gross Assorted Small Expansion Springs ⅜" to 1½" long, 3/32" to 3/16" diam., 21G to 24G. 6/6 each.



No. 1013. 1 gross Small Coil Compression Springs, ⅜" to 1½" long, 3/32" to $\frac{3}{16}$" diam., 24G to 19G. 6/- each.



No. 753. 3 doz. Assorted Light Expansion ¼" to ½" diam., 2" to 6" long, 22 to 18 S.W.G. 10/6 each.

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Your reactions as an engineer might have been adverse if this mechanical short cut had been submitted to you on paper.

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Besides being extraordinarily simple, the device has many great advantages: for one, the release lever plate needs no sliding bearing, neither does the carbon thrust block.

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Automatic
Preselection of
Co-ordinate Settings

completely eliminate Jigs and Fixtures!

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June 22nd — July 6

THIS FULLY AUTOMATIC CO-ORDINATE BORING MACHINE is entirely new in its CONCEPTION

Pre-selection of co-ordinate settings in either direction.

Settings made to .0002" using unique system of end gauges held in totally enclosed magazines.

Pre-selection of spindle speeds. Speeds and feeds checked by means of tell-tale lamps and illuminated preselectors.

Slides automatically clamped when in boring position.

Work table accessible on three sides.

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Table can be completely removed, allowing machining of large bulky components. Infinitely variable milling feed.

No damage done to the machine by incorrect manipulation of controls. Loading of slideways always uniform.

Punched card automatic programming built into machine.

Control boxes can be supplied for up to 28 holes.

Machine suitable for fine milling in both directions.

Machine employs standard electro-mechanical and built-in hydraulic units only—no electronics.

Precision depth measuring attachment included in standard equipment.

BRIEF SPECIFICATION

Longitudinal Spindle traverse	50"
Cross Spindle traverse	30"
Working area of Table	38" x 58"
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Maximum distance spindle to Table	31"
Down feed of spindle quill	13"
Vertical power adjustment of Table	17"
Spindle taper	No. 40
18 spindle speeds from	35 to 1800 r.p.m.
9 Boring feeds, from	.002 to .098"
Milling feeds, infinitely variable, from	0 to 9" per min.
Rapid traverse	150" per min.
Total power	14 h.p.
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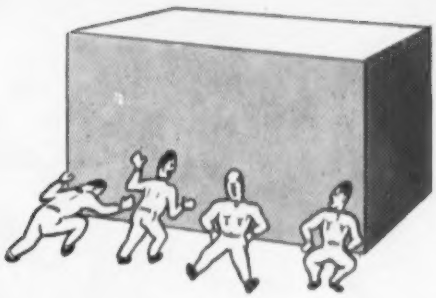
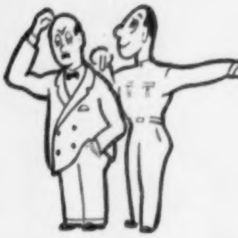


Solve your handling problems



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EARLS COURT · LONDON · 9-19 MAY 1956

The greatest display of mechanical handling equipment the world has ever seen, packed with devices for reducing costs and increasing output, takes place at Earls Court in May.

This is the place to solve every materials handling problem. Here you can inspect labour-aiding equipment, large and small, for every industry, light or heavy. Whether your requirements involve only a modest device or a large-scale installation, they can be met.

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The world's largest display of labour-aiding devices in the world's largest exhibition hall.

Over 400,000 square feet of space, showing every type of equipment, large and small, from a simple trolley to elaborate coal-handling gear and ingenious bottling plant.

Something to save time, cost and effort in every industry from mining to milling.

Many working exhibits, with experts to advise on your special problems.

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Please send the 1956 Exhibition brochure with details of Convention and free season ticket, etc.

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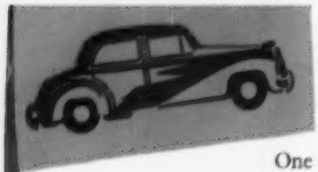
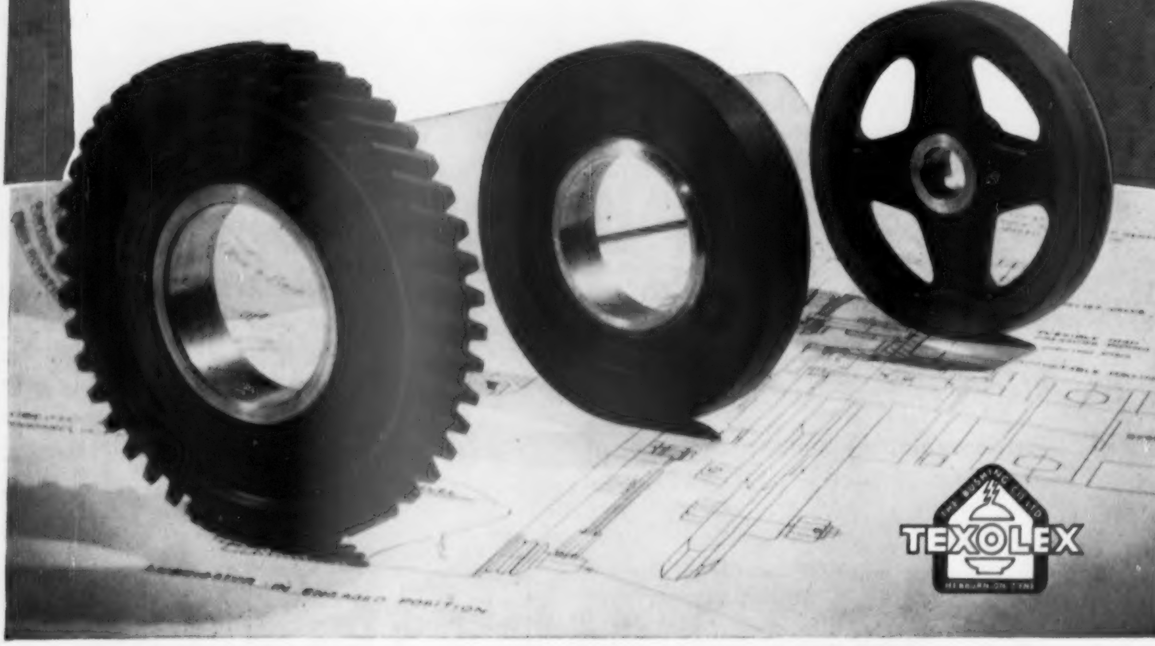


PLASTICS FOR THE ENGINEER

One of the many industrial applications of Texolex laminated mouldings is in the motor industry where extensive use is made of this material for cam gears. Some of the largest motor manufacturing organisations have found in Texolex many of the qualities of the ideal material, offering silence in operation, lightness in weight, high mechanical strength coupled with resistance to wear and corrosion.

TEXOLEX IN THE AUTOMOBILE INDUSTRY

The Bushing Company Limited, would be pleased to give further technical information about Texolex laminated fabric gears and their suitability and operation in camshaft, jackshaft and oil pump drives.



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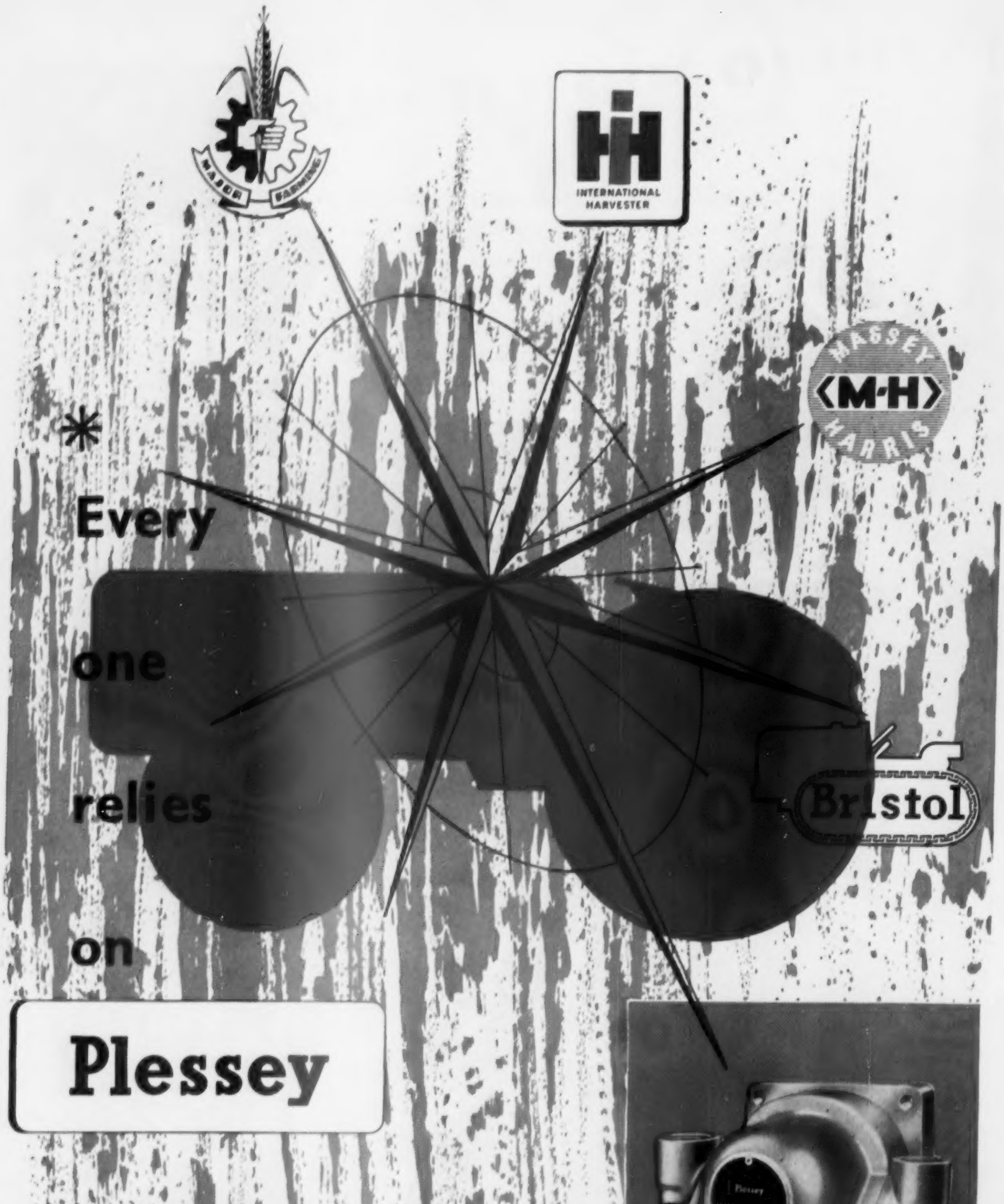
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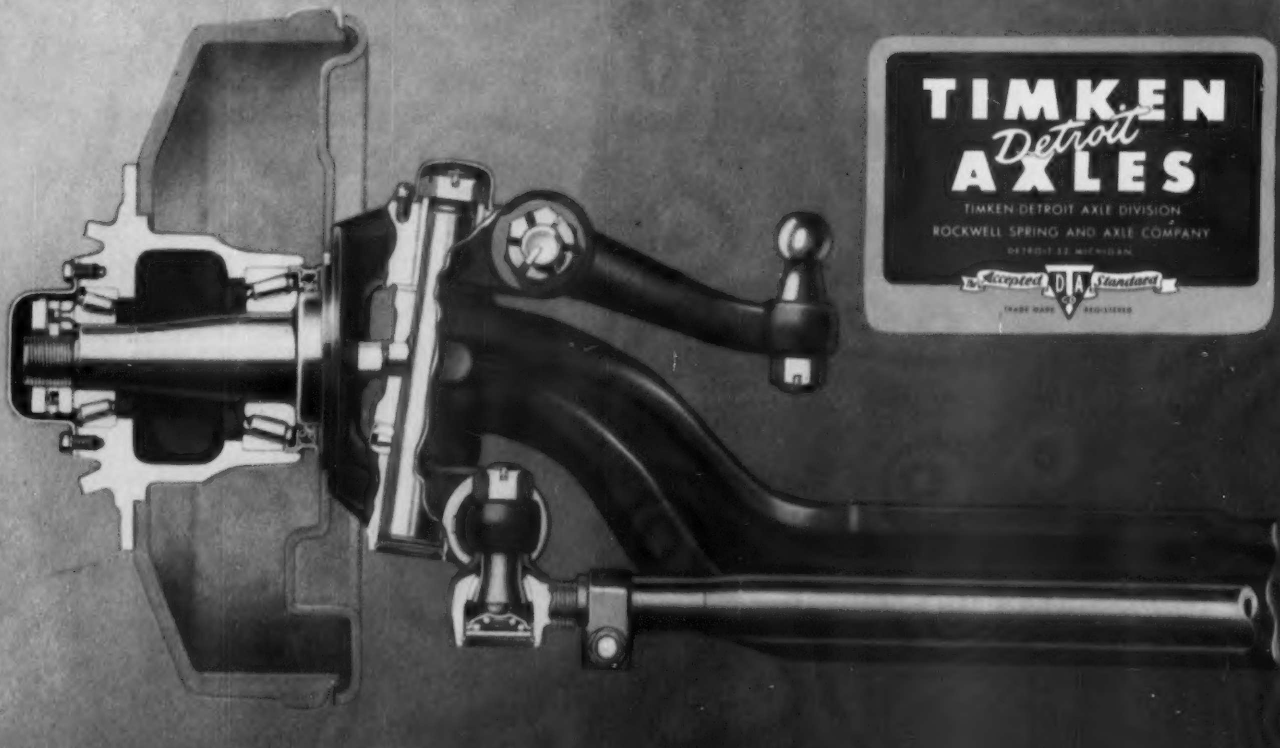

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TIMKEN-DETROIT AXLE DIVISION
ROCKWELL SPRING AND AXLE COMPANY
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These heavy duty axles embody Timken-Detroit's unique experience in vehicle axle engineering. They incorporate many features conducive to great strength and long life, and many which materially assist the driver in handling the vehicle.

The following are important 'strength' features: full I-section axle beam: generous-sized stub axles with large-radius fillet: seal runs on large diameter land and cannot start dangerous 'stress-raising' scores. Generous steering knuckle with interchangeable bushings: tapered seating of king-pin in axle-beam. Substantial lock-stop.

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GUARANTEE: Timken roller bearings for two years, other axle parts for one year, against defective material or workmanship when used on vehicles of specifications approved by us.

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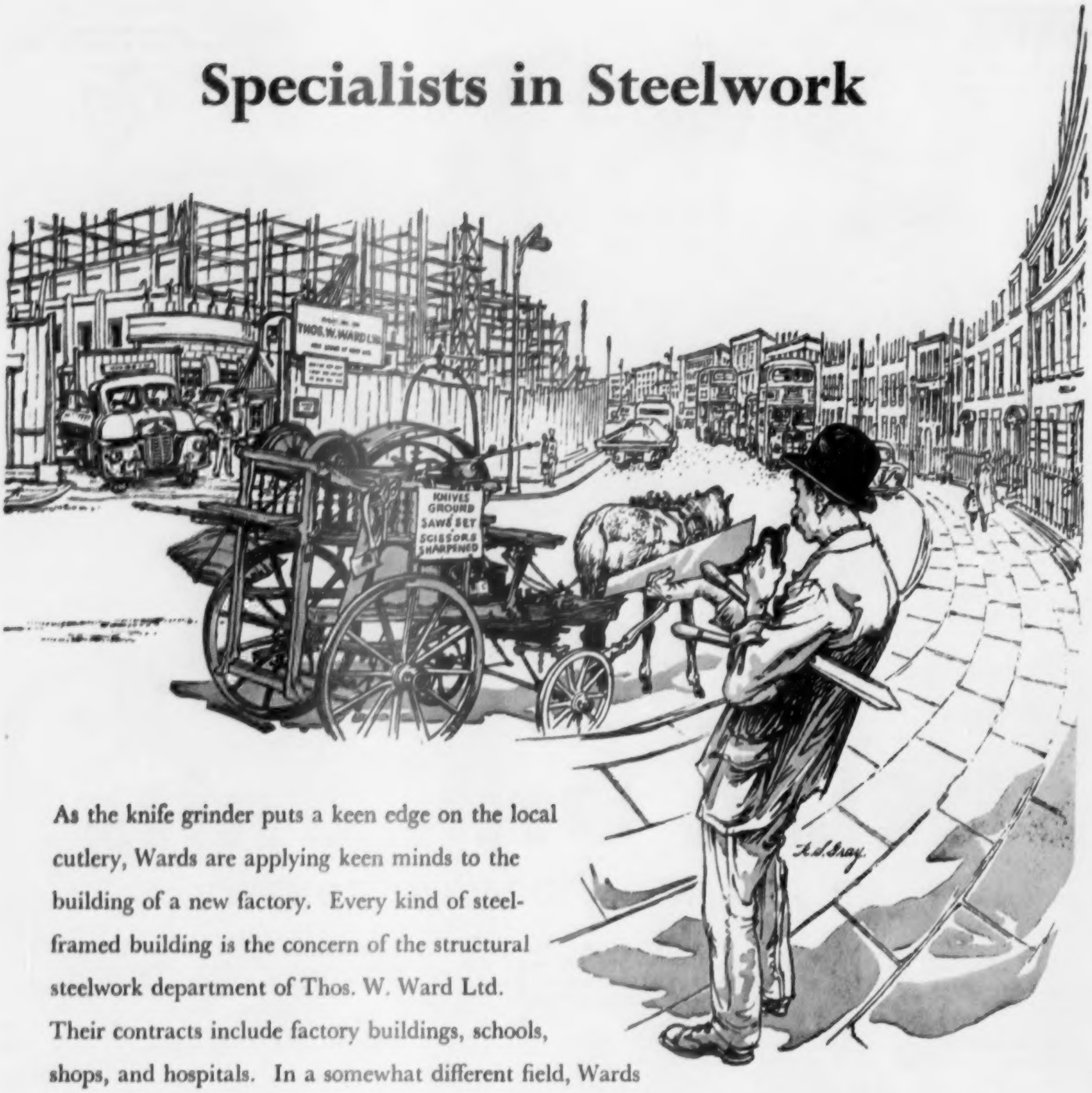

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THE SPARCATRON process of spark erosion by which all electrically conducting materials can be machined to a high degree of accuracy is especially valuable for machining hard metals. In the reconditioning, repair or alteration of dies and press tools the process offers many advantages. A die for hot brass stamping sink gratings was worn to the point of scrapping after 10,000, but the cavity was refaced and the die restored to its original condition by spark machining. The cavity in a hardened steel die for forging turbine blades measured about 5 × 1 in. In a few hours metal to a a depth varying from 0.005 to 0.01 in. was removed to restore the impression, then the die face was ground to correct the depth. A die can be re-cut several times and it has been found that a spark erosion reconditioned die will give longer service than in its original condition. Similarly, a hardened die mould or press tool can be corrected or altered by the SPARCATRON process when it is not possible or too costly by other methods.

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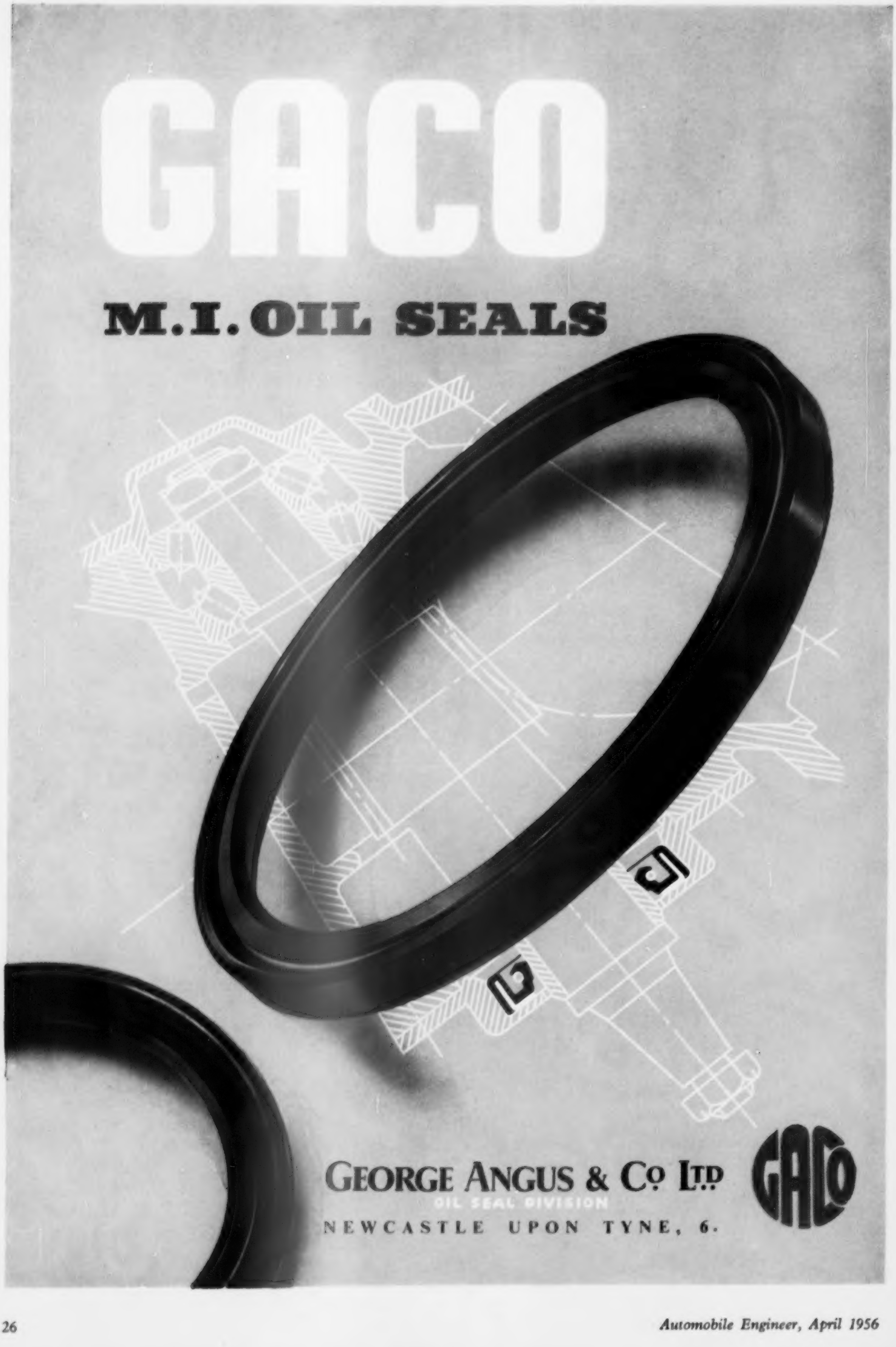
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Yield Point:	16 tons p.s.i.	Yield Point:	21 tons p.s.i.
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Strength Rigidity

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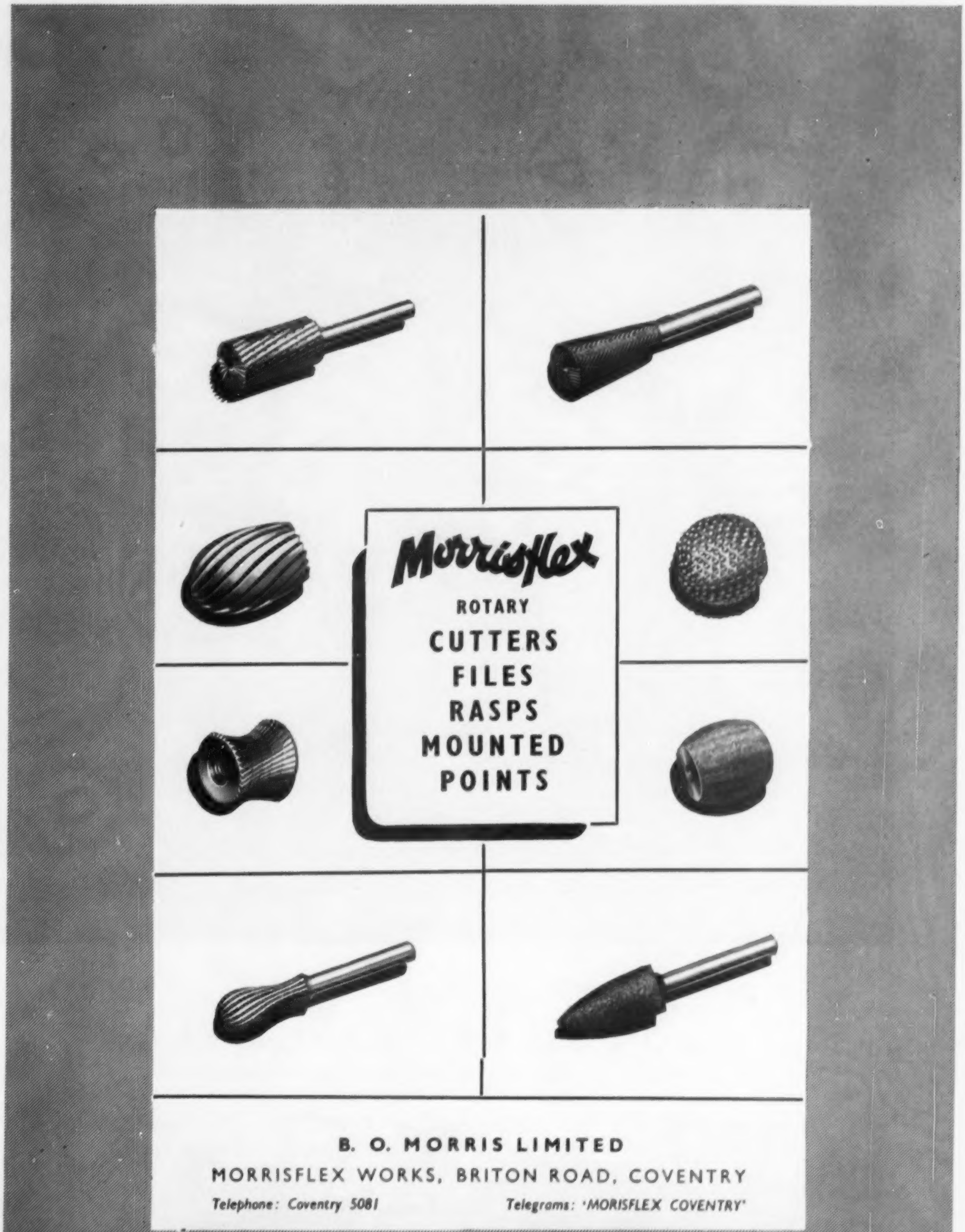
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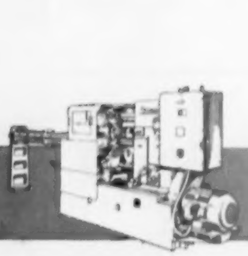

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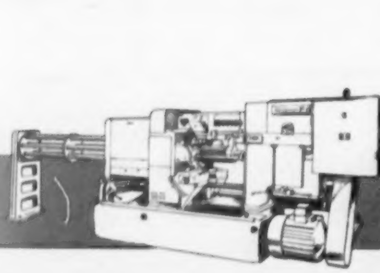
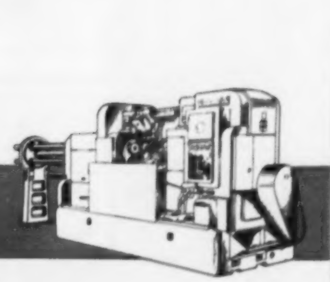
Spindle speeds 247—3030 r.p.m.



2" — 6 Cycle times 7—602 secs.
Spindle speeds 111—1302 r.p.m.



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Automatics

Throughout the World, production engineers whose daily concern is the high-speed output of turned metal parts are looking to automatic equipment for the solution to the insatiable and unprecedented demands of the mass-producing industries.

More and more are finding the solution in the Wickman range of multi-spindle automatics. With a background of nearly twenty years development and a fine record of high-production service to the metal-working industries these machines offer an immediate and lasting solution to the problem of rising labour costs, higher overheads, and the handicap of limited factory space.

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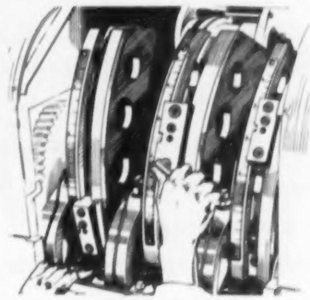
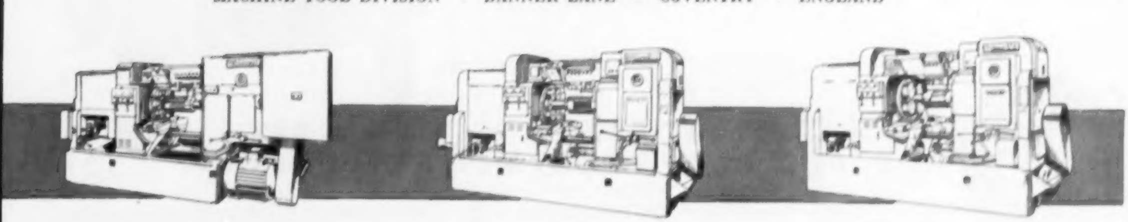


WICKMAN LIMITED

MACHINE TOOL DIVISION · BANNER LANE · COVENTRY · ENGLAND



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makes good sense

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★ Long upsetting ram guide-ways completely enclosed.
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★ Simplified tool adjustment and faster change-over.
(Punch and die change 15-20 minutes)
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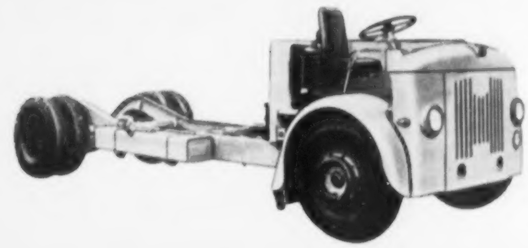

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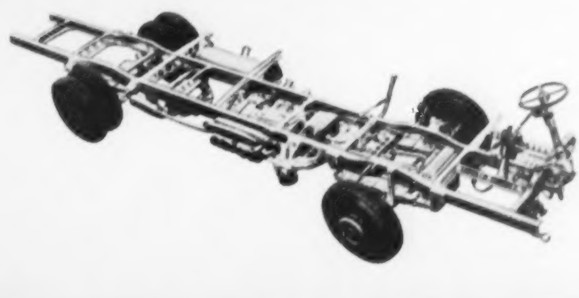

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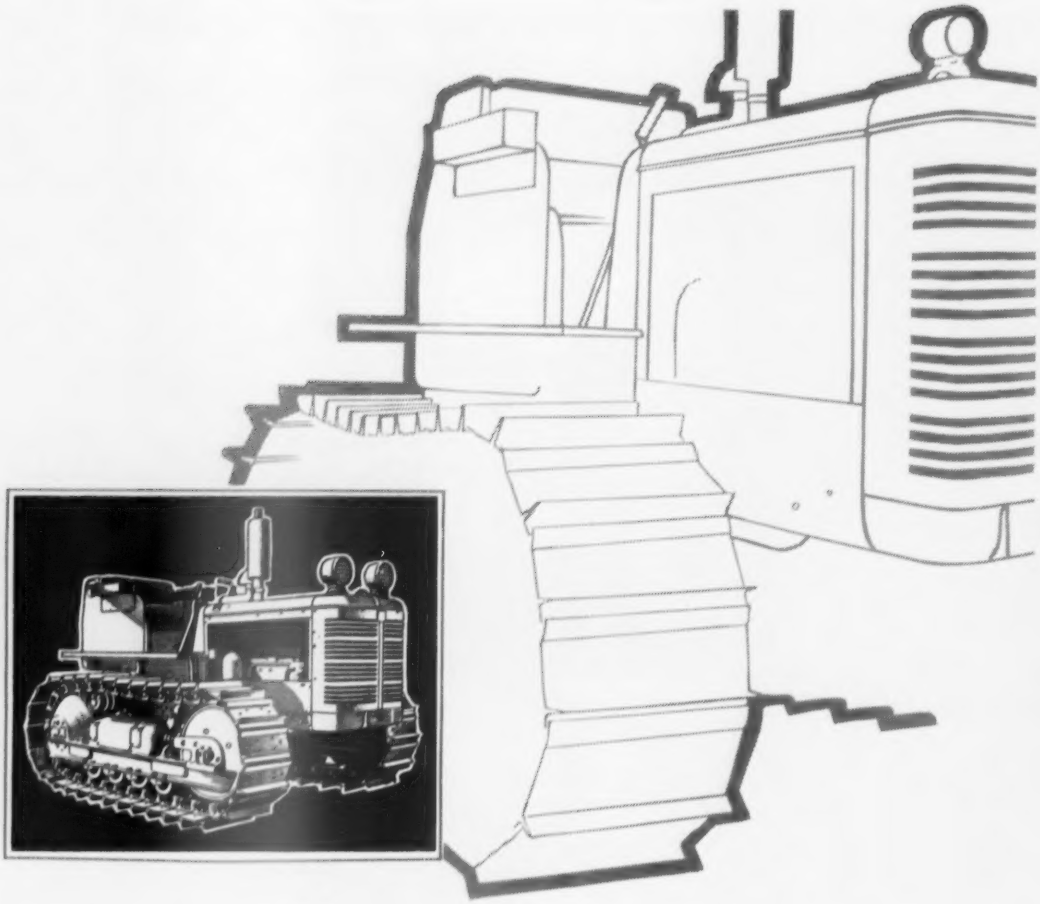


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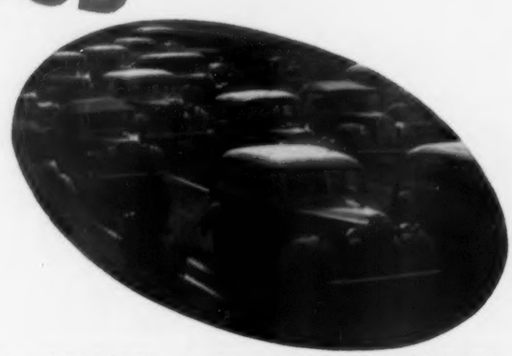

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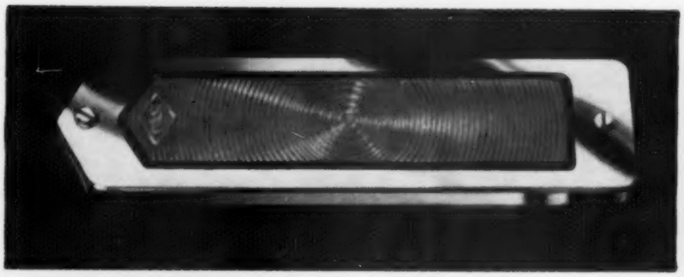

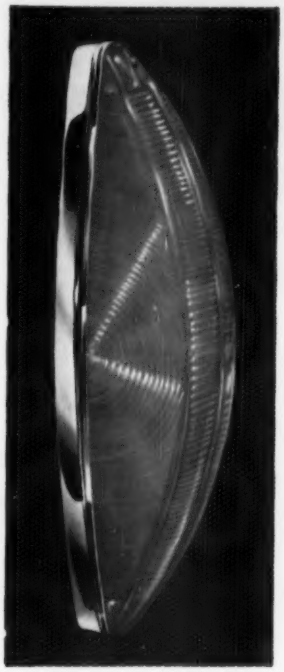

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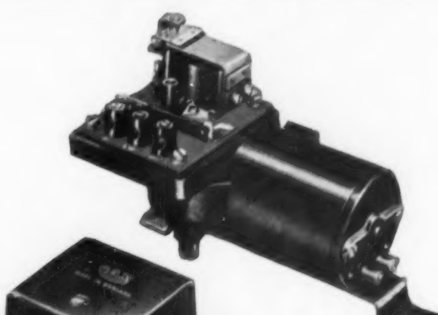

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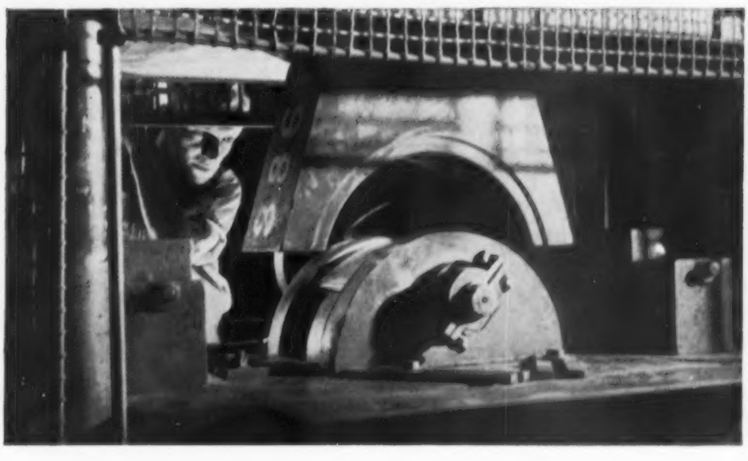

This spirit of research lives on at Chapel-en-le-Frith. In the laboratory and Test House of the Ferodo factory, scientists and technicians still search for new materials, new methods of manufacture, new standards of safety and dependability. Whatever developments may come in the automobile industry, you may be sure that Ferodo Limited will have friction materials ready to match them.

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New high power 'unit type' motor

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Range for capacities of ⅜" and ½"

For capacities of ⅜" and ½", Consolidated Pneumatic has introduced the 3075 range of drills with offset handles. These also have the new 'unit type' motor giving 50% more power. They can be supplied with chucks for deep hole woodboring up to 1" diameter. The introduction of these new lines into the already extensive CP range provides a complete selection of small tools for all classes of work. This includes impact wrenches for nut running operations and a very complete selection of aero riveters. The CP range of grinders, too, are all of the modern steel-clad design. Full details of all these tools are provided in literature freely available on request.

This CP-3008 Screwdriver has a supersonic exhaust to reduce noise, is only 9" long and weighs under 2 lb.

Four speeds are available in the Model CP-3017 Drill for capacities of ¼" to 5/16" all with offset handles, but lever type throttle is optional.

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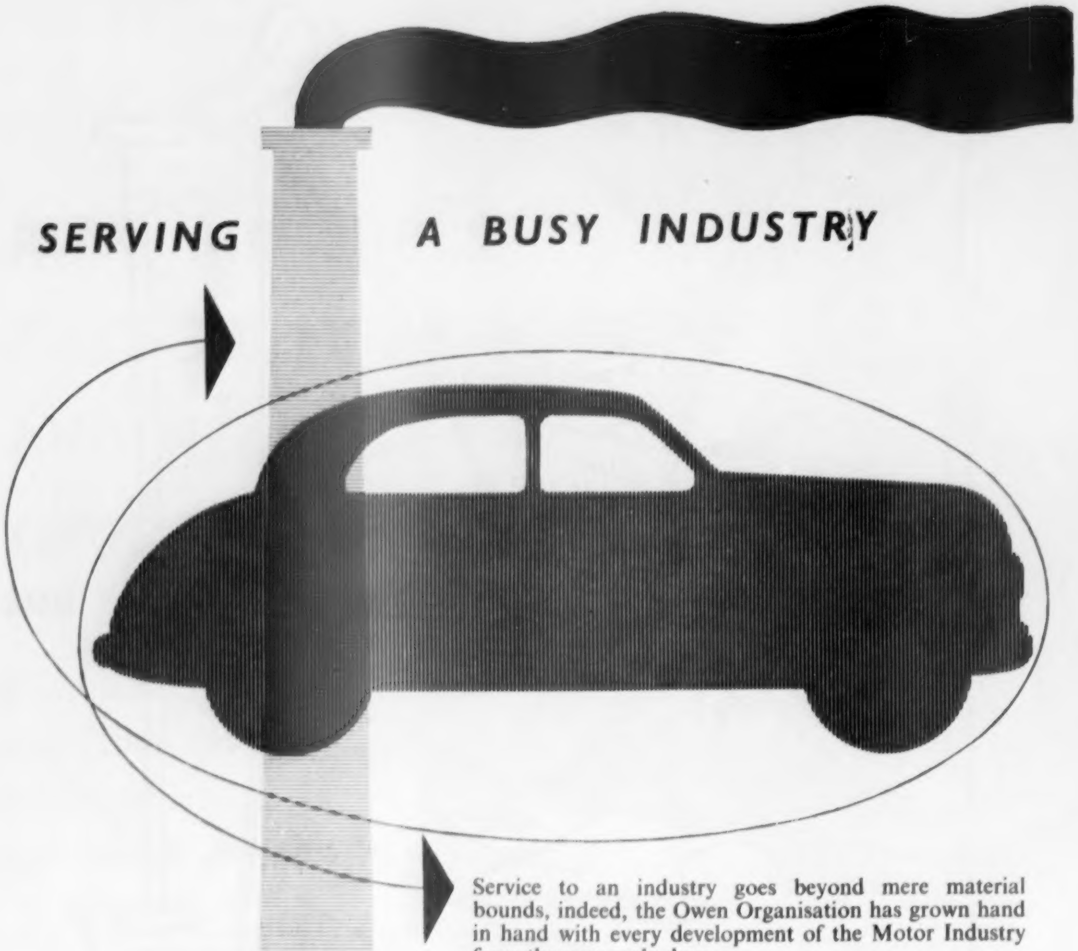

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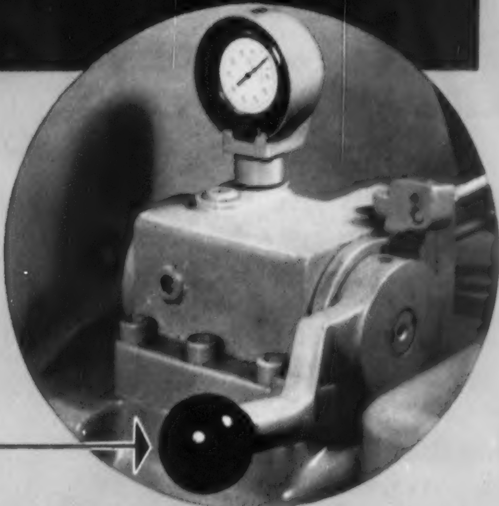

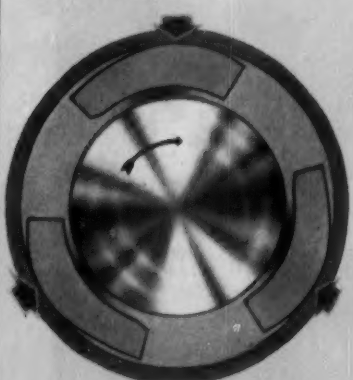

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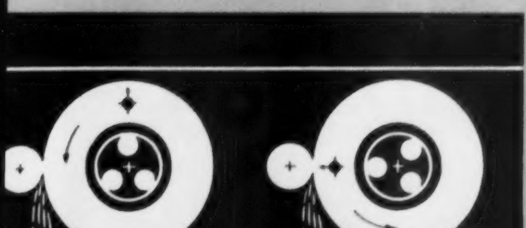

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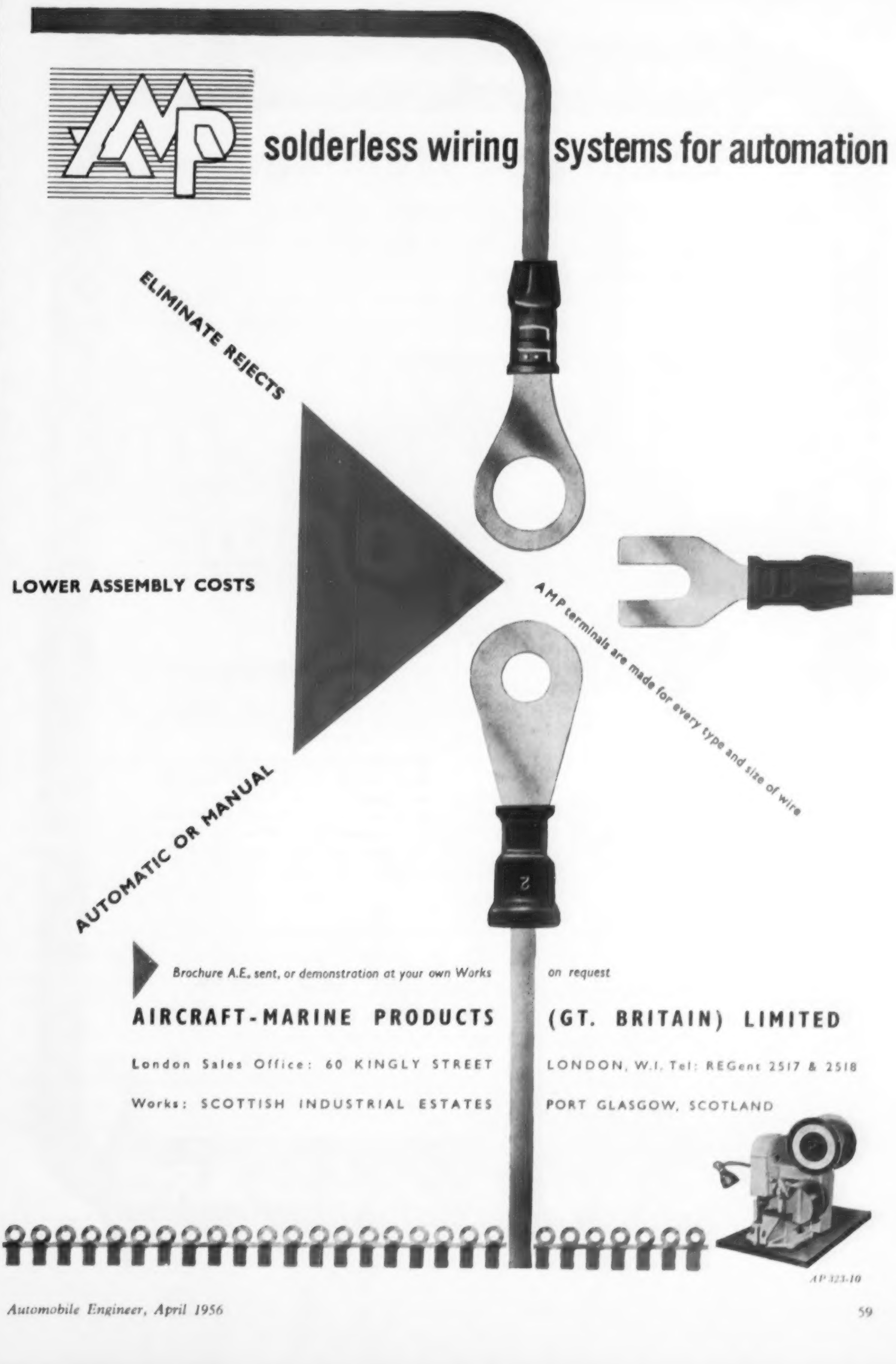
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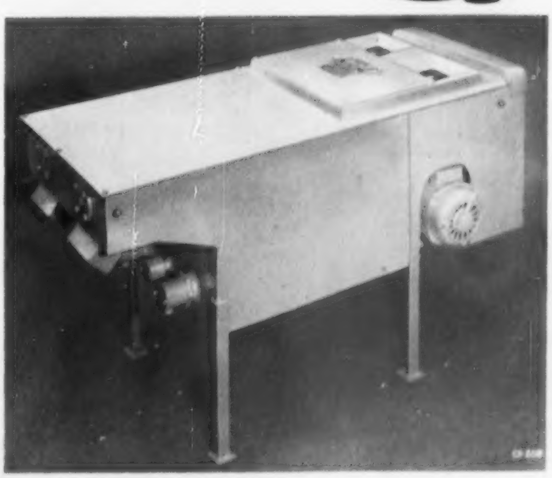

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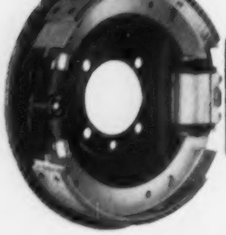

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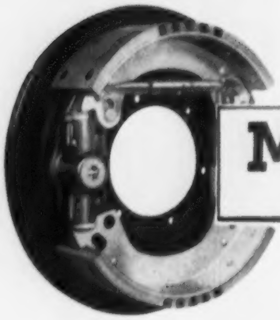

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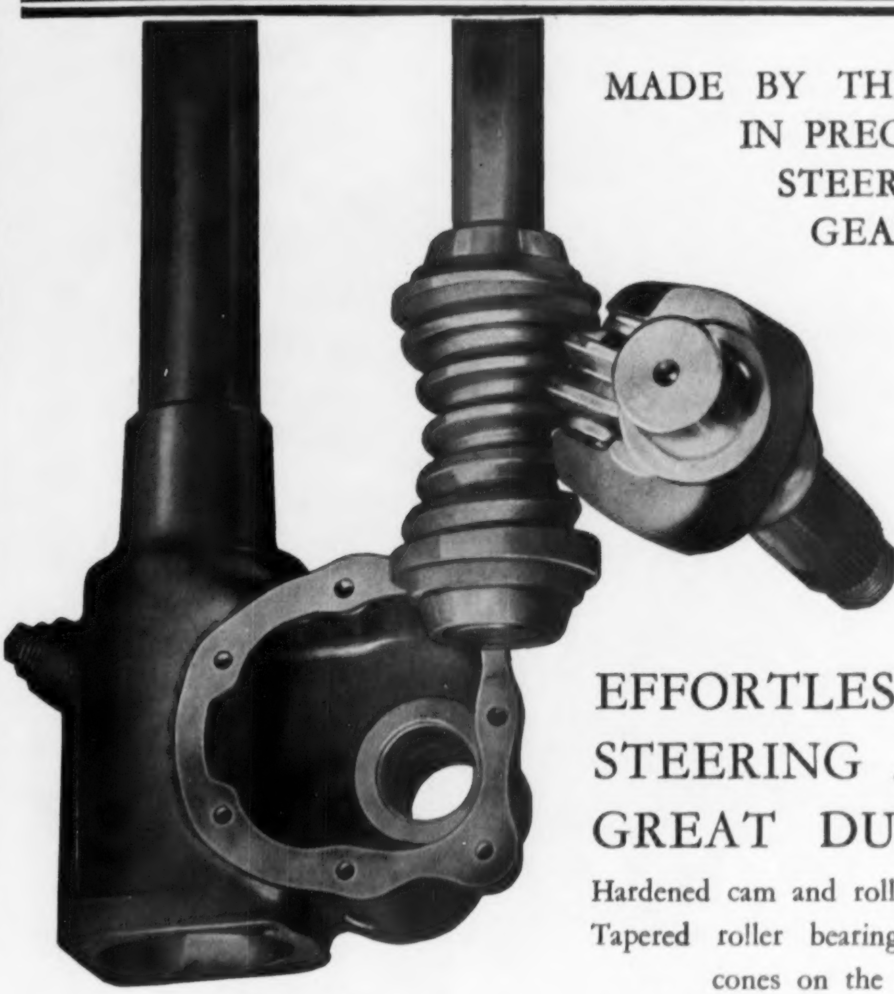

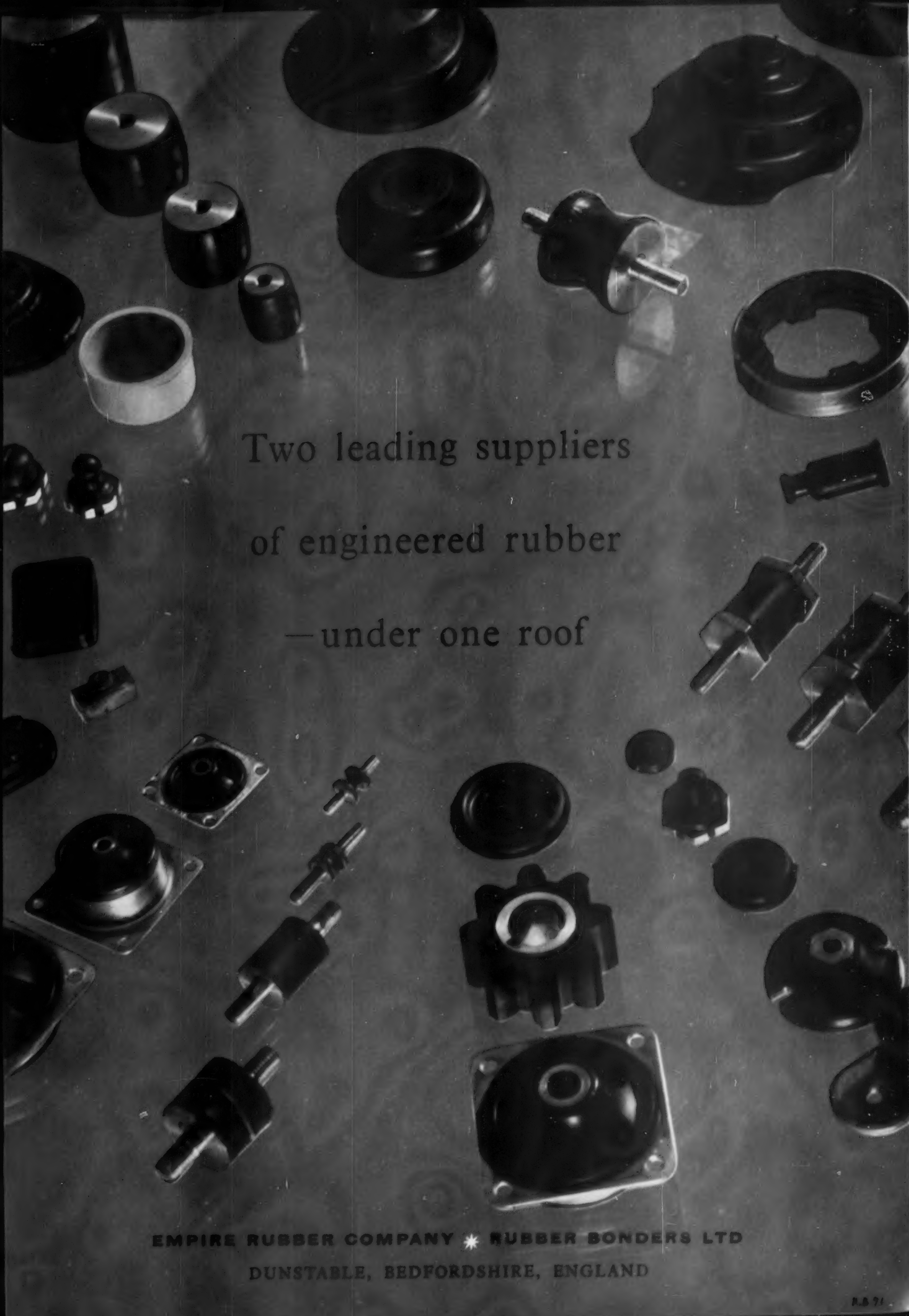
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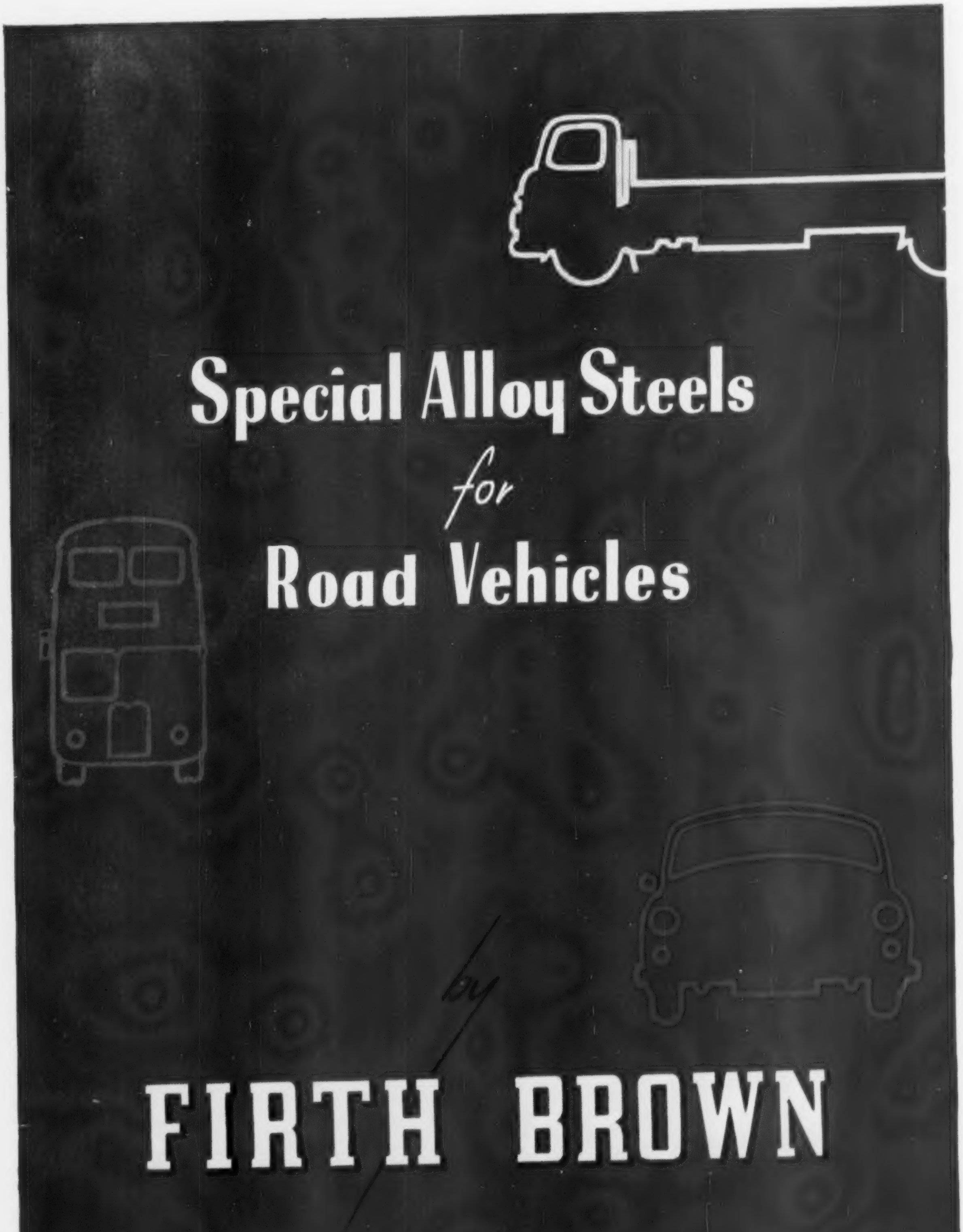
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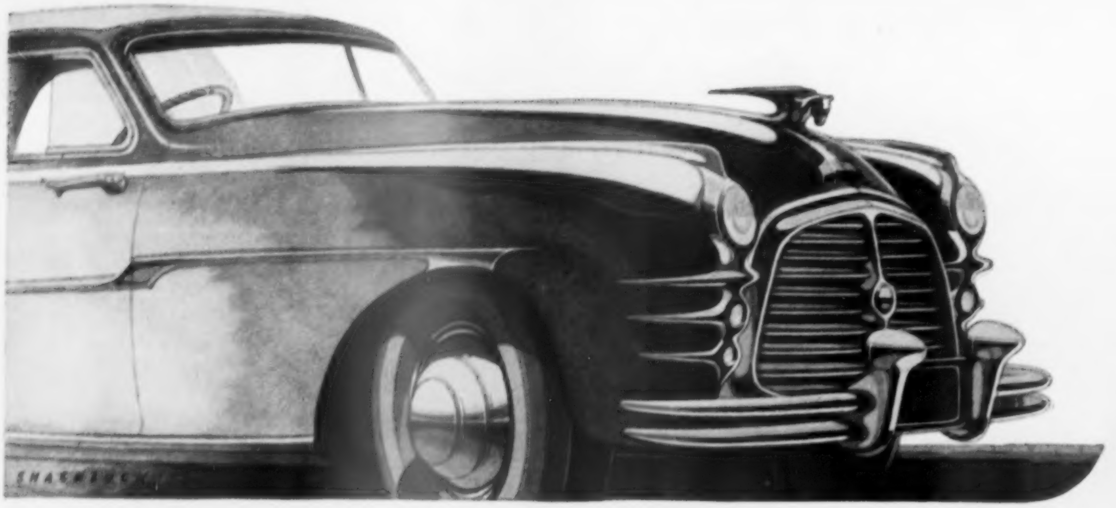


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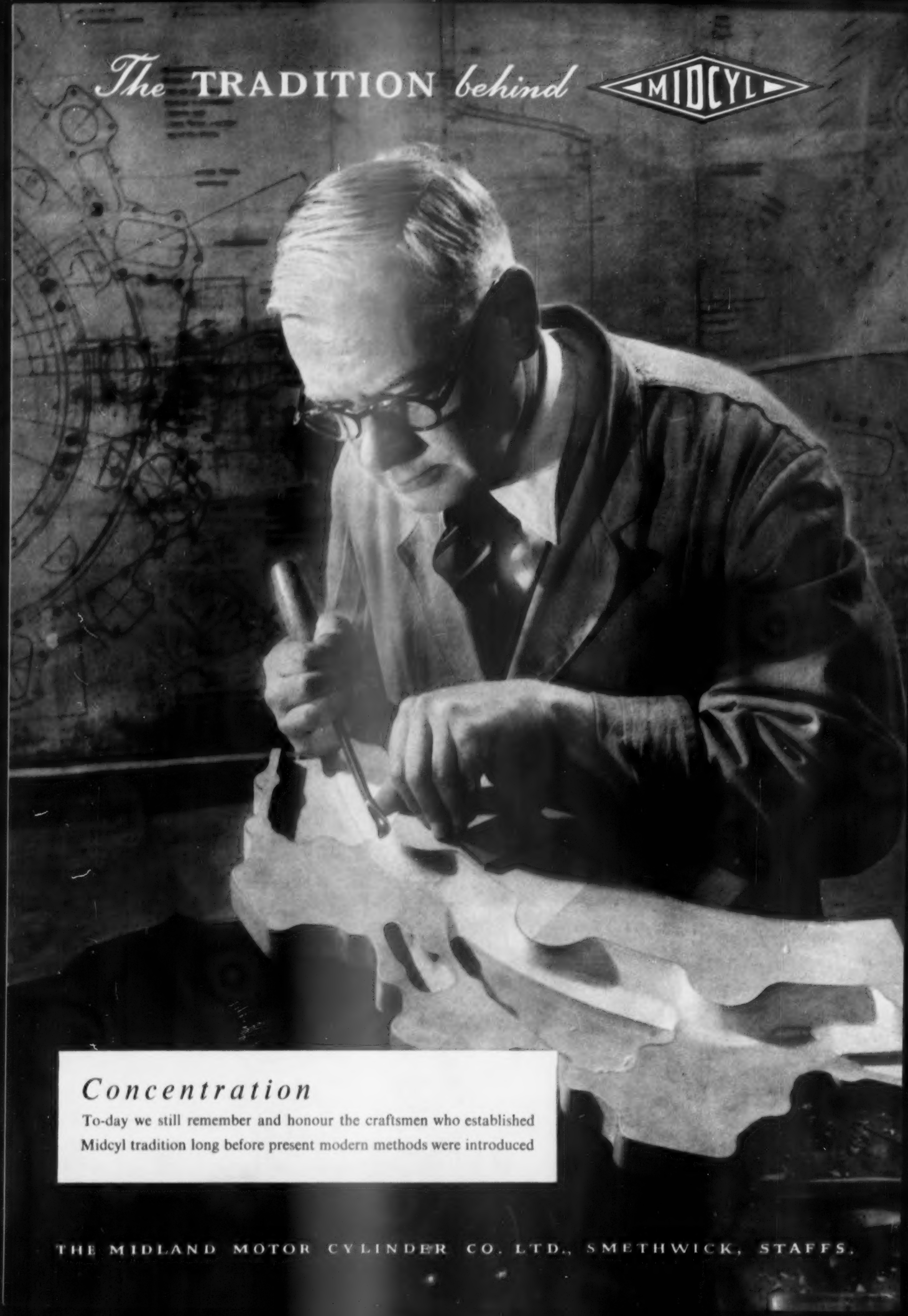
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AUTOMOBILE ENGINEER

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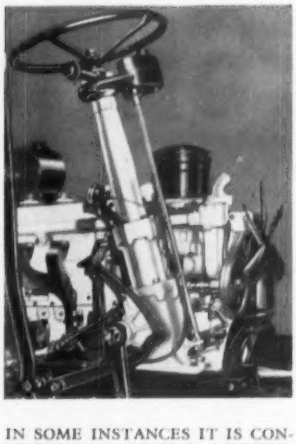

IN SOME INSTANCES IT IS CONVENIENT TO INSTALL A POWER-ASSISTED STEERING UNIT AT THE BASE OF THE STEERING COLUMN. THIS ILLUSTRATION IS OF THE LOCKHEED UNIT IN THE DAIMLER FREELINE CHASSIS

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Editor J. B. Duncan

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F. C. Sheffield

DESIGN MATERIALS **AUTOMOBILE ENGINEER** PRODUCTION METHODS WORKS EQUIPMENT

Rear Engines

EVERY time a rear-engined car is introduced, because British manufacturers do not adopt this lay-out, there is a certain amount of caustic criticism, usually not well informed. There are, of course, two main disadvantages to the rear-engine arrangement, a tendency to marked oversteer and inadequate luggage accommodation. For many years these drawbacks were considered sufficiently serious to make cars to which they applied unsuitable for competition in world markets, with cars of more conventional layout. However, the developments during the past few years show that this no longer holds good.

That Renault, after a number of years' experience with the 4CV, have introduced another model of this type, the Dauphine, will undoubtedly encourage further criticism of the British automobile industry. However, the introduction of this model, viewed in its true perspective, cannot be regarded as a sound argument for the adoption of the rear-engine layout, even for the smaller British cars, although no one will deny that there are advantages as well as disadvantages in the arrangement.

So far as the Renault organization is concerned, there were sound reasons for using the same type of arrangement for the Dauphine as for the 4CV. In the first place, this allowed the maximum standardization of components common to both models, so that commitments in respect of new tools were minimized. Moreover, the new and old models can be produced side-by-side on the same production line so that the dislocation of production that is inevitable when extensive re-tooling has to be undertaken has been avoided. Another production advantage, and not a small one, is that the relative outputs of the larger and smaller models can be easily adjusted to suit fluctuations in demand.

The trend of events indicates that Renault will feel themselves to be committed to this layout for another seven years or more. Therefore, barring unforeseen developments, the design may have a total run of about twenty years before radical changes are made. This situation is not without parallel, since the experience of other manufacturers of rear-engined cars, and for that matter of front-wheel-drive designs also, has evidently been similar. This certainly underlines the seriousness with which a decision to change to an unconventional layout must be considered.

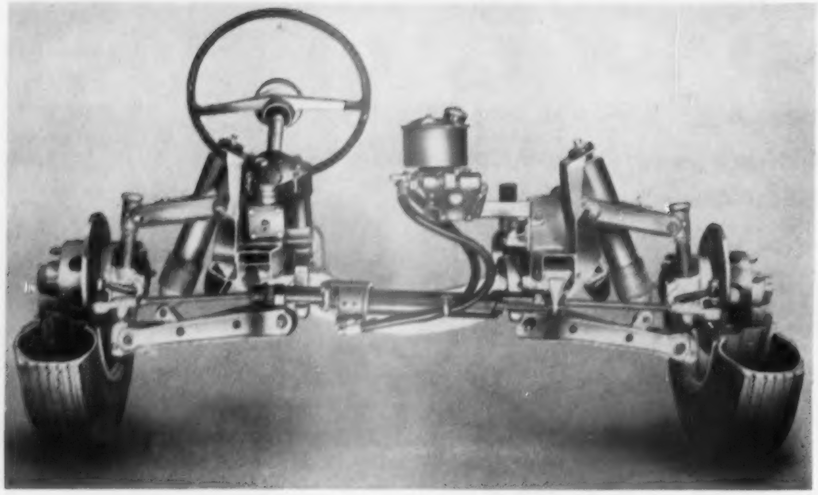
It is of interest to study the fundamental design changes that have been made to improve the Dauphine in comparison with the 4CV, because they do give an indication of the lessons learned from experience. The disadvantage of inadequate luggage space has been in great measure overcome. This has been effected by increasing the length of the bonnet and the height of the scuttle—an arrangement that does not spoil the proportions of the car, since the 4CV was exceptionally short—and the increase in height has been offset by a downward slope of the bonnet towards the front.

In comparison with the 4CV, the handling characteristics have been improved by increasing the wheelbase and by lengthening the vehicle. This addition to the length, of course, has increased the space available for passengers, and has also allowed the front passengers to be seated further forward so that a greater proportion of their weight is taken by the front wheels. Nevertheless, the increase in the length of the bonnet, despite its advantage in providing more space for luggage, is in other respects a retrograde step. This is because it is contrary to the primary aim in adopting the rear-engine layout, which is to provide the greatest possible interior space within a given overall length.

For larger cars, where good handling characteristics and comfort are more important considerations than economy in space, there is scarcely any merit in the rear engine layout. For small cheap cars there is a case, though not an overwhelming one, for its adoption, on the grounds of production economy, this case would be strengthened a little if independent rear suspension were to become regarded as an essential feature of passenger cars.

There can be little doubt that by combining the best features of different models, even better designs than those already in production could be evolved. For example, by the adoption of the general arrangement of the Dauphine, with the rear suspension of the Fiat 600 and the wide track of the Volkswagen, most of the disadvantages inherent in the rear-engine type of design might, to a large extent, be overcome.

The crucial point for the British manufacturer is, of course, whether a change from the conventional layout would lead to greater exports. To that question, we are certain, the answer is "No." Nor are we forgetting the spectacular advance made by a rear-engined car in export markets during the past two or three years, as this advance is in spite of, and not because of, the engine layout.



A mock-up of a front suspension assembly incorporating a Lockheed power-assisted steering installation and a low pressure, rotor type hydraulic pump unit

LOCKHEED POWER-ASSISTED STEERING

A Range of Units Designed for Different Types of Application

TWO different types of Lockheed power-assisted steering units are manufactured by Automotive Products Co. Ltd., Leamington Spa. One is the integral type, in which the power assistance unit is built into the steering gear at the base of the column. In this category, there is the Daimler Freeline installation. The second is the linkage type, which can be made either as a one-piece unit incorporating both the valve and the steering jack, or as a two-piece unit, in which these two components are mounted separately on the vehicle. The makers favour the one-piece arrangement.

With the integral type, the complete installation can be simpler than that of the linkage type, provided the vehicle is designed specifically for this power steering layout. It also could be more economically produced in large quantities. Other advantages of this layout are that the system is compact, and mechanical losses, which are an important factor so far as sensitivity of the valve is concerned, are less than in some of the linkage arrangements. As a general principle, the valve should be as near to the steering wheel as possible, to minimize lost motion between it and the wheel. On the other hand, it is also desirable in many instances to apply the power as close as possible to the road wheels. This minimizes the loading on the linkage and reaction points and reduces the resistance to the self-centring action of the road wheels. In general, therefore, the arrangement adopted is a compromise. On some vehicles, it is easier to accommodate the integral type of unit, and on others the linkage type. It is of interest that in America, where power steering is much more widely employed than in this country, the two systems are almost equally popular, although there is a trend towards the increasing adoption of the linkage type. This is because the linkage arrangement can be adapted more readily to existing vehicle designs, so there is a wider scope for its application, and since it is therefore made in larger quantities, its cost is lower. This trend is also apparent in Britain.

Each of these systems can be operated on either the continuous flow or the constant pressure principles. With the continuous flow arrangement, an open-centre type of valve is employed and the hydraulic fluid from the pump flows continuously through it. Power assistance is obtained by diverting some of the flow to one side or the other of the piston in the jack.

With the constant pressure system, when the valve is in the neutral position, all the valve ports are blanked off and so there is no fluid flow. This system requires the incorporation of an off-loading valve to prevent the pump from running under pressure all the time and thus absorbing an excessive amount of power and wearing out rapidly. The hydraulic accumulator, the primary function of which is to store energy, also prevents the off-loading valve from fluttering or at least from being overworked. Because the jack is under pressure all the time and the valve movement, which is very small, is a function of the rate at which the jack has to be moved, the constant pressure type of steering valve is generally very sensitive. However, the constant flow type of valve is the simpler of the two. The constant pressure system is employed in some applications where stored energy is in any case required for other services, such as brakes, or where it is necessary to have power assistance even when the engine is not running. This system has the advantage that the energy stored in the accumulator can be used for short periods at a rate that is independent of the pump capacity. Therefore, a relatively small pump can be used and the volume of fluid continuously circulating is low.

At present, so few manufacturers and operators have had experience with power-assisted steering systems in service that opinions as to the requirements, so far as actual steering characteristics are concerned, differ widely. Currently, it is generally thought that power assistance should be such that the effort required on the steering wheel to turn the road wheels from lock to lock on dry concrete should be no more than about 15 lb for a private car and 30 lb for a medium weight truck. The amount of power assistance given varies as between one application and another. In some, only 12 per cent of the work is done by the driver and in others the figure is as much as 30 per cent. It is of interest to note that when power was first applied to operate aircraft controls, it was thought desirable for the pilot to do a proportion of the work required to actuate the control so that he did not lose the feel of the machine. Now, with fully power operated flying controls, an artificial feel-back is transmitted to the pilot. Therefore, it seems possible that power steering, as distinct from power-assisted steering, may ultimately become popular at least for the heavier classes of road

vehicles. However, conditions under which road vehicles operate are, of course, vastly different from those which apply to aircraft. Fully powered systems are currently employed on some vehicles used off the road.

Some authorities maintain that it is necessary to retain a feel of the road in order to be able to detect whether or not the surface is icy or greasy: others hold that because of the high steering ratios currently employed and the low efficiency of steering gears in transmitting loads from the road to the steering wheel, it is more useful to have an artificial feel that gives an indication of the angle at which the road wheels are deflected from the straight-ahead position. It is also thought that when the feel-back is artificial, there may be a danger of over-stressing the steering gear. However, this could probably be catered for by the incorporation of a relief valve in the system. The provision for direct mechanical operation in the event of failure of the hydraulic system is more difficult when fully power-operated systems are employed.

There are two methods, both of which are widely employed, to transmit the feel-back from the road to the steering wheel. With one system, the manual effort of the driver is applied to the steering linkage, generally through a spring. When the resistance to movement of the wheel exceeds a certain value, the spring is compressed and the hydraulic valve moves relative to the system to bring in power assistance. At the same time, hydraulic pressure on reaction areas of the valve slide gives the feel-back. The other method is to rely entirely on a reactive valve. In other words, the hydraulic pressure in the pipe line serving the jack is applied to a secondary piston on the valve, that is, the reaction area, so that movement of the valve is resisted in proportion to the degree of power assistance given. Lockheed favour this reactive valve method, mainly because the spring of the first system has to be accurately manufactured and preloaded, and so tends to be expensive.

Although the steering box ratios currently adopted are mostly the same with power steering as without, it is probable that the future trend will be to employ a lower ratio if power-assisted steering is incorporated. It is essential that the self-centring properties of the system should be adequate to avoid the driver having continually to steer the car in order to maintain it on a straight course. A very efficient mechanical system within the power assistance unit is also necessary, otherwise the valve is likely to have stick-slip characteristics and to be subject to false signals. Current American practice, with regard to rates of steer, is to provide for movement from lock to lock in 3 sec for passenger cars and light trucks, and in 4-6 sec for heavy trucks. This method of defining rates of steering does not appear to be entirely satisfactory: it would be better to specify a rate of turn, in degrees per second, of the road wheels about the swivel pins; furthermore the wheelbase dimension should be taken into consideration, since the important factor is the rate of change of turning circle.

Among the types of pump employed by Lockheed are the Hobourn-Eaton unit, which is an eccentric rotor type pump, and a multi-barrel plunger pump of their own manufacture. The rotor type pump is suitable for applications in which the open-centre type valve is employed and in which the operating pressures are relatively low. Most of the Lockheed systems in which this type of pump is employed operate at pressures of up to about 700 lb/in². However, if a closed-centre valve is used and the operating pressures are high, in the order of 1,200 lb/in², as in the tractor installation described later, the plunger type pump is best. High pressure systems can be made more compact than low pressure ones, but sealing is more difficult and the cost in general is higher.

So far as the output of the pump is concerned, the flow requirement is related to jack displacement, but for most power steering systems on private cars it is about one gal/min at 550 r.p.m., so that manœuvring for parking can be carried out with the engine at idling speed. For a medium weight truck, the requirement at this speed might be about $1\frac{3}{4}$ gal/min. It is desirable that the output should be increased by about 1·7 times up to 1,000 r.p.m., and thereafter should remain constant as the speed is further increased. In other words, a metering valve operating on the flow control principle must be incorporated to limit the output and also to give a free-flow back to the reservoir to keep the power absorption of the pump to a minimum. It is also necessary to incorporate a pressure relief valve to guard against the development of excessive pressures, which might damage seals or other components. Pulsation of the flow should be kept to a minimum. The eccentric rotor type pumps give an output that is inherently relatively free from pulsations. If a plunger pump is employed, it must be of the multi-element type.

LINKAGE TYPES WITH OPEN-CENTRE VALVE

The principle of all the linkage type units with open-centre valves, developed by Lockheed, is similar. They differ only in arrangement, in that the valve and cylinder assembly can be installed separately, as in the two-piece arrangement, Fig. 1, or they can be mounted together either in-line or side-by-side, as in Figs. 2 and 3 respectively. In the example illustrated, in Fig. 3, the steering unit is mounted transversely in the vehicle, one end being supported by the steering drop arm and the other by an idler lever. The piston rod is of cyanide hardened En 32 and is chromium plated. One end has the piston, which carries two cast iron rings, spigoted and welded on to it, while the other is carried by a two-piece flanged rubber bush in an eye at the lower end of a pendant link, which is pivoted at its upper end on a bracket on the frame. The axis of the pivot is parallel to that of the jack, and the purpose of the link is to accommodate displacement of the steering jack and valve assembly in a direction normal to its axis. This displacement arises, of course, because the ends of the drop arm and idler lever move through an arc of a circle.

At one end, the rod is supported by the piston, and at the

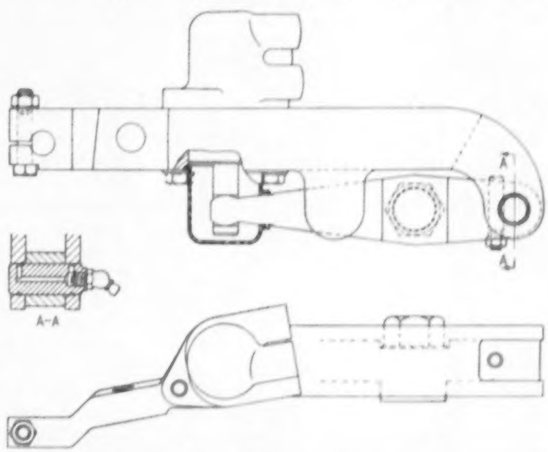


Fig. 1. In the two-piece arrangement, the steering valve is sometimes attached to the drop arm, as in this illustration

other end by an En 8 guide, which is spigoted and welded into the end of the jack. This guide carries in a counterbore in its outer end a multiple-seal assembly, at the inner end of which is a U-section, high pressure seal. An aluminium washer is carried next to the seal to support it. Outboard of this washer is a low pressure, spring-loaded lip type seal, which ensures that the rod, as it moves on its outward stroke, is wiped dry so that abrasive matter will not adhere to it. Finally, a close-fitting, phosphor bronze wiper ring is

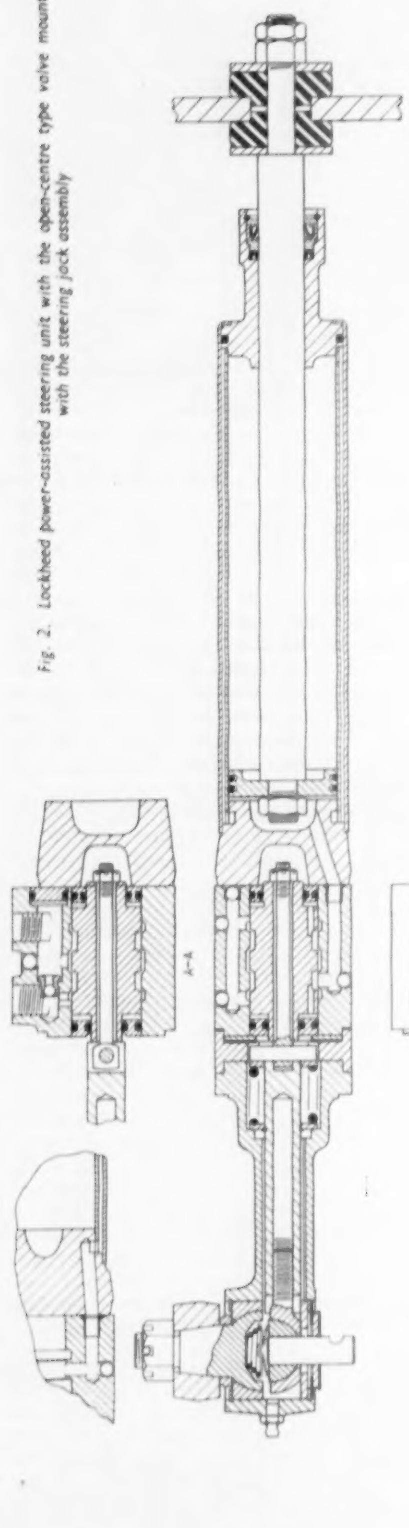


Fig. 2. Lockheed power-assisted steering unit with the open-centre type valve mounted in line with the steering jack assembly

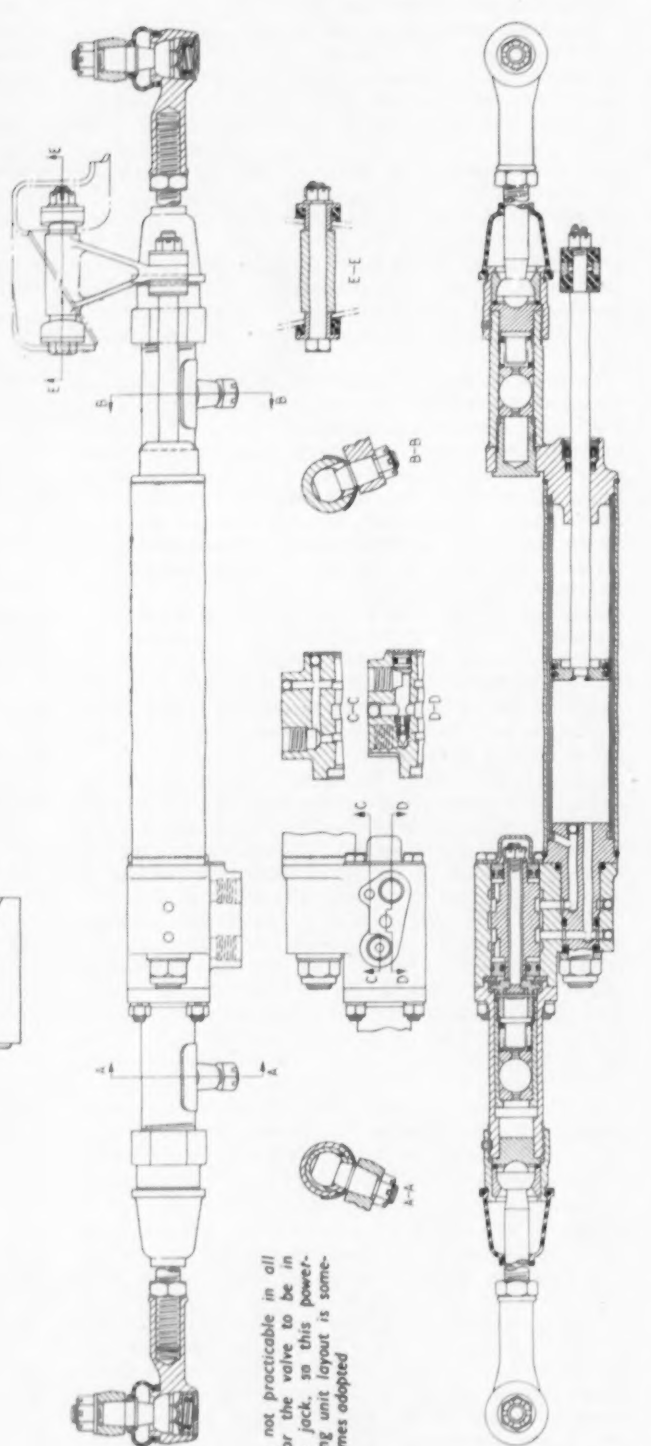


Fig. 3. It is not practicable in all installations for the valve to be in line with the jack, so this power-assisted steering unit layout is sometimes adopted

assembled into the housing to prevent foreign matter from entering the seal assembly as the rod moves on its inward stroke. The whole assembly is retained by a snap ring in a groove in the counterbore in the outer end of the guide. An eye is forged integrally on the side of this guide to receive two ball joints: one forms the attachment to the steering idler lever; the other is the connection to the steering rod of the adjacent road wheel.

At the other side of the unit, the ball joints for the steering rod and drop arm are carried on the end of the valve housing, which is of close grained cast iron and is alongside the En 8 plug that closes the end of the cylinder. In common with most power steering units of this type, the drop arm is in fact connected to the valve slide, which is of En 32. To make this connection, an adaptor is bolted to the slide and then screwed into the end of the housing for the ball joint on the drop arm. When the adaptor is screwed into the housing it applies the precompression to the coil spring that provides automatic adjustment for wear in the ball joint. Interposed between the end of the spring and the adaptor is a flanged stop to limit the motion of the ball joint relative to the valve slide. This stop is spigoted into the spring, which seats on its flange, and the flange in turn seats on the end of the adaptor. The outer end of the adaptor is counterbored to receive the head of the bolt that is passed through an axial hole, in both it and the slide, to secure the two components together. Movement of the valve slide is restricted by the flange round the adaptor; this flange is a clearance fit in a groove round the housing, and the clearance determines the total amount of valve movement obtainable.

The centre portion of the hardened steel valve slide is about $1\frac{1}{4}$ in diameter, and has two annular grooves in its periphery. Its diameter is arrived at by compromise: a large diameter is required to allow the fluid to flow through the grooves as freely as possible, but on the other hand, the larger it is the greater the mechanical friction resisting movement of the slide. Each end of the slide is turned to a smaller diameter than the centre. Since these ends form the reaction faces against which the hydraulic pressure acts to give feel-back, they are of different areas to compensate for the difference between the areas on each side of the piston in the jack. The smaller reaction area is subject to the pressure on the side of the piston where the area is restricted by the piston rod, and the larger reaction area is subject to the pressure on the other side of the piston. A sleeve forming a seal housing is fitted over each end of the slide. In the bore of this sleeve is an annular groove in which is a U-section, high-pressure oil seal, while round its outer periphery is another annular groove that houses a circular section, rubber sealing ring. This simple ring is, of course, adequate to seal the outer periphery because it does not slide in the housing, whereas the more elaborate seal is needed in the bore because there is relative motion between it and the valve slide.

An eye on one side of this valve housing receives the spigot-end of the plug that seals the end of the cylinder. Two flexible hoses are connected to the slide valve housing, one is the fluid inlet and the other is the return to the tank. There are three annular grooves in the bore of this housing. The outer two are connected to the inlet from the pump, and the centre groove to the return pipe. To form the connections to the two ends of the cylinder of the jack, which is double-walled, two holes are drilled radially through the two lands that separate these three grooves and the end plug of the cylinder. One is connected by passages in the plug to the adjacent end of the cylinder, and the other is connected to the annular space between the inner and outer sleeves that comprise the double-walled cylinder. The oil passes along this space to the other end, and thence through radial holes into the cylinder.

When the valve is in the neutral position, the land between the two grooves on the slide is in line with the centre groove in the housing, and the lands on each side of this centre groove are in line with the two grooves in the slide. All the grooves are slightly wider than the lands opposite them, so oil can flow from the high pressure, or outer, grooves in the housing, through the grooves in the slide and return through the centre groove in the housing to the tank. Movement of the valve in either direction from this neutral position causes one high pressure groove in the housing to be blanked off and the other to communicate with one of the grooves in the slide, through which the oil flows to the hole in the adjacent land in the housing and thence to one end of the jack. The other groove in the slide moves into communication with the centre, or return, groove in the housing, so the oil from the other end of the jack can flow through the hole in the other land and these two grooves and thence back to the tank. Thus the pressure on one side of the piston is increased and the jack casing moves relative to the piston until the valve is centralized again.

Holes are drilled from each groove in the slide to its adjacent ends so that in all circumstances, the pressure applied to each side of the jack is also applied to the appropriate reaction area. This, by resisting the movement of the valve by the driver, provides the necessary feel back. A non-return valve is incorporated between the inlet and the outlet pipes. It is normally held in the closed position by the pressure of the delivery, but should the pump fail, it is unseated so that the reservoir does not become overfilled owing to displacement of fluid from one side of the jack and cavitation on the other side.

STEERING COLUMN UNIT

The steering column unit illustrated in Fig. 4 is that employed on the Daimler Freeline chassis. It differs from the units already described not only in layout, but also in that a constant pressure system of operation, at about 1,200 lb/in^2, is employed in conjunction with a closed-centre valve. This form of valve has not such a free self-centring action as the open-centre type, but it is suitable for certain types of vehicle. The unit consists of two main components. One is the valve, which is mounted on the steering column, and the other is the cylinder and piston assembly interposed between the steering column and the drop arm. A conventional worm and nut gear is housed in the upper end of the steering column. At the lower end of the nut is a ball thrust bearing to actuate a two-piece connecting rod. The upper piece of this rod has a purely axial sliding motion, and the lower portion connects the upper one to the swinging lever that actuates the steering drop arm. Eyes are formed at each end of the lower half of the rod, which is of H-section. They are bushed to carry the pins by means of which the connections are made. The sliding portion is hollow and is forked at its lower end to receive the eye on the upper end of the H-section piece. Immediately above this fork is carried the piston of the hydraulic jack. Thus, the power assistance is applied through the piston to the upper portion of the connecting rod.

Integral with the piston is a sleeve, which extends down into the lower portion of the casing, which houses the drop arm pivot bearings and actuating lever. A rectangular section rubber seal, with a small rectangular section moulded rubberized fabric insert in a counterbore in its outer end, is retained by a plain ring and snap ring sprung into the groove round the bore of the cylinder. This seal bears on the periphery of the sleeve extension of the piston, where it passes from the cylinder into the lower portion of the casing. The rubberized fabric insert is incorporated to prevent the softer rubber of the seal from being extruded into the clearance between the sleeve and its bearing in the upper end of the steering

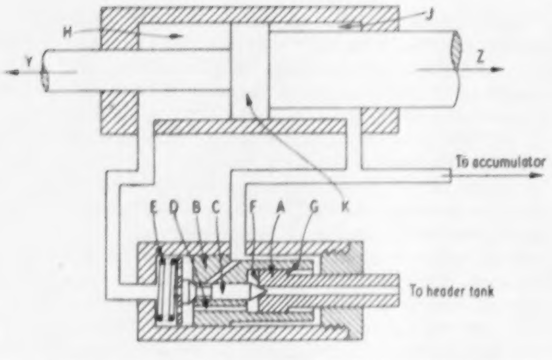


Fig. 5. Diagrammatic illustration showing the principle of operation of the steering valve for the steering column unit

box. To ensure that hydraulic pressure is applied to the inner end of the seal, so that the rubber is compressed to contact firmly both the bore and the sleeve, the plain ring is a fairly good fit in the bore of the cylinder but has about $\frac{1}{8}$ in clearance between its inner periphery and the sleeve.

The sleeve is of such a diameter that the annular area of the piston head round it is half the area on the other side of the piston. Therefore, to maintain the balance of forces, the pressure in the chamber between the sleeve and the cylinder must be double that on the other side of the piston. For this reason the piston is equipped with a U-section rubber and fabric seal, fitted in the space between it and the sleeve extension, to bear on the bore of the cylinder. The end of the sleeve adjacent to the piston is internally flanged. A ring nut pulls this flange up against the shoulder of the fork-end of the upper part of the connecting rod. A rectangular section, rubber seal is fitted between the shoulder and the flange in the sleeve. All the pressure seals in this unit have a fabric backing.

A large diameter cast iron plug is spigoted into the upper end of the cylinder. It is flanged and clamped between the flanged ends of the cylinder and the steering column. A rectangular rubber sealing ring is housed in a groove round the spigot. The centre of the plug has a hole in it to form the bearing, or guide, for the hollow upper portion of the connecting rod. A U-section rubber seal is housed in a counterbore in the inner end of this bearing. This seal, as well as that round the piston, has a wedge-section ring, spring-loaded into the channel between the arms of the U to ensure that they do not collapse when the hydraulic pressure is released. Each of these seal and spring-loaded ring assemblies is retained by a circular plate secured by countersunk set screws to the outer face of the housing.

The valve, the movement of which normally is only about 0·003–0·004 in in either direction, is actuated by a bell crank lever, one end of which projects through a slot in the column and registers in a longitudinal groove in the periphery of the nut. The axis of the pivot of the lever is parallel to that of the nut, rotation of which actuates the lever. This rotation is limited to a relatively small amount by fixed stops in the valve assembly. The other end of the lever is forked to fit in a grooved collar screwed on to the end of the valve push rod. There is no backlash in the valve itself.

The method of operation of the valve can be understood clearly by reference to the diagrammatic illustration, Fig. 5. Torque applied to the steering worm in either direction is also applied to the nut and therefore to the lever that actuates the valve. Thus, the force applied to the valve is directly proportional to the applied torque and the jack thrust is directly proportional to the load applied at the steering wheel. If the jack tends to overrun, the valve is unloaded and returns to neutral.

To effect movement of the ram in the direction Z, the push rod A is moved inwards and the needle valve C displaced from its seat on the sleeve B, against the opposition of the spring E. This displacement of the needle valve allows fluid to flow from the accumulator into the chamber H until the pressures in chambers H and J are equalized. However, the force exerted upon the smaller area of the ram is only one half that on the other side, so the ram moves in direction Z, the fluid displaced from chamber J passing, together with the fluid from the accumulator, through the valve into chamber H.

Movement of the push rod A in an outward direction permits the spring E to return the needle valve C on to its seat on the valve sleeve B. At the same time, the other end of

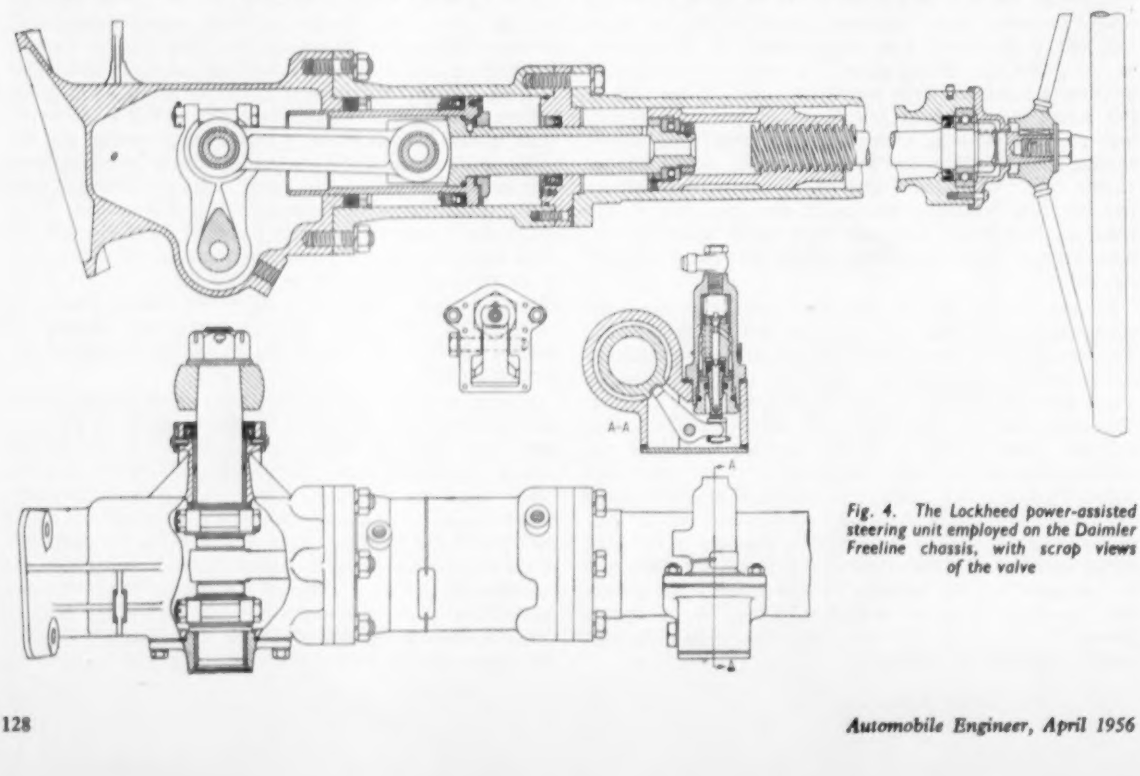


Fig. 4. The Lockheed power-assisted steering unit employed on the Daimler Freeline chassis, with scrap views of the valve

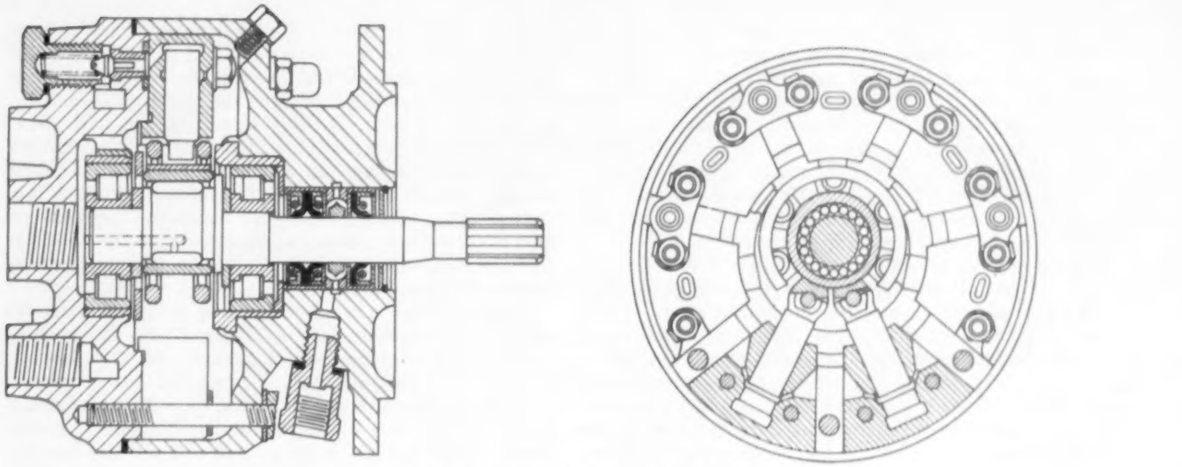
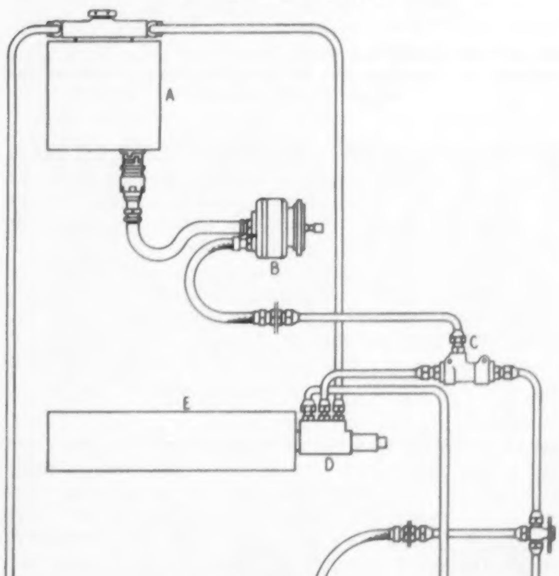


Fig. 7. Arrangement of the Lockheed Mark 7, seven-cylinder radial plunger pump

the needle valve is unseated from the end of the push rod so that fluid in the chamber H can escape through port D to the header tank in the following manner. Fluid exhausted through the hollow stem of the push rod in the valve enters the chamber that houses the valve actuating lever and thence passes into the steering column tube. From there it goes down the centre of the hollow portion of the connecting rod between the steering nut and the H-section link, and thus passes into the lower portion of the casing, whence, an external pipe carries the fluid to the header tank. The maintenance of fluid in the whole of the unit ensures that all

Fig. 6. Diagram showing the layout of the power-assisted steering arrangement used on the cross country tractor

A *Reservoir* **B** *Pump* **C** *Metering valve* **D** *Cut-out valve* **E** *Hydraulic accumulator* **F** *Steering valve* **G** *Steering jack*



moving parts are adequately lubricated. This effects a material reduction in wear and friction losses.

When the wheels are deflected from the straight ahead position and the steering wheel released, the self-centring torque of the wheels increases or decreases the pressure in chamber H, and the process of force balancing on each side of the piston continues until the road wheels are centralized. In other words, the pressure in chamber H rises or falls until it attains a value equal to one half that in chamber J. For example, if the pressure in chamber J, and therefore in the line from the accumulator to the valve, is greater than twice that in chamber H, the valve C is forced off its seat and fluid passes to chamber E. Since the area of the annulus G is half that of F, the needle valve C closes when the pressure in chamber E is half that in the pipe line from chamber J and the accumulator to the valve. Thus, there is a tendency for the push rod in the valve assembly to remain automatically in the neutral position unless disturbed by externally applied load. It reverts to the neutral position, in which there is no appreciable resistance to any external force applied to the jack, when the applied load is removed. If the wheels are deflected by an obstacle in the road, the deflecting force tends to rotate the nut in such a direction that power assistance is brought to bear to oppose the motion. In the event of failure of the hydraulic system, steering can be effected mechanically in the normal manner.

A SYSTEM INCORPORATING BOTH OPEN- AND CLOSED-CENTRE VALVES

Lockheed have designed a power steering system in which both the open- and closed-centre types of valve are incorporated. The advantages of this arrangement are as follows. Under normal operating conditions, it gives the free self-centring action of the open-centre valve arrangement; the energy stored in the accumulator is available to meet demands for abnormally high rates of flow, and to operate the system when the engine stops; a small high-pressure pump is employed so the jack installation is compact. By the employment of the differential area principle of operation, the design of the valve has been simplified. The system illustrated is employed on the 6×6 C.T., 10 ton tractor.

The layout of the system is illustrated in Fig. 6. From the header tank the fluid flows to the engine-driven pump and thence to a metering valve. Two connections are taken from the metering valve: one goes to the cut-out valve, and the other to a three-way connection. A hydraulic accumulator is screwed on to the end of the cut-out valve, and there are two more connections on this assembly: one is the return

from the valve to the tank, and the other is the pressure line from the accumulator to the closed-centre portion of the steering control valve. One of the pipe lines from the three-way connection is the delivery from the metering valve, already mentioned. The second is to the end of the actuating jack in which the piston rod is housed, that is, to the chamber adjacent to the smaller area of the piston. Finally, there is the connection through the open-centre portion of the steering control valve to the other side of the jack, that is, to the chamber closed by the larger area of the piston.

A metering valve is incorporated to ensure that one gallon per min of the flow from the pump is delivered to the continuous flow portion of the valve; the flow in excess of this passes to the cut-out valve, which keeps the accumulator in a fully-charged condition, that is, at a pressure of 1,750-2,250 lb/in². This ensures that a reserve of power is available when the flow is inadequate for continuous flow operation. The relief valve for the continuous flow circuit is in the steering valve, while that for the accumulator is in the cut-out valve. This arrangement obviates the need for a relief valve in the pump.

Pump. A Lockheed Mark 7, seven-cylinder radial plunger pump, Fig. 7, is employed. It is a constant delivery type unit, the plungers of which are actuated by an eccentric shaft. The pump can be driven in either direction without alteration. A relief valve is not incorporated in the design. The rated maximum working pressure is 3,000 lb/in², at which pressure the minimum delivery is 3¼ gal/min at 4,000 r.p.m. Under these conditions, the unit absorbs 8·2 h.p. The manufacturers state that the pump will tolerate over-speed running at 5,200 r.p.m. for five minutes at a delivery pressure of 3,000 lb/in².

The eccentric shaft that actuates the plungers is integral with the driving shaft, and the whole of the interior of the pump is filled with the fluid. An annular groove, forming the inlet port, is cut in the bore of each cylinder in such a position that it is partly uncovered just before the plunger reaches the bottom of its stroke. When the plunger is moved up the cylinder for a short distance, it closes the inlet port, and the trapped fluid is forced through a passage leading from the outer end of the cylinder. Thence the fluid passes through a non-return valve into an annular passage in the end cover, which it leaves through the outlet connection.

Metering valve. Fluid enters the metering valve, Fig. 8, through a radial connection A in the side of the unit and can leave through two connection B and C, one at each end. The flow through these outlet connections, one of which is to the cut-out valve and the other to the open-centre portion of the steering control valve, is regulated by a double-ended needle valve in the centre of the unit. This valve is coaxial with and carried by a piston that slides in the bore of the unit. The valve and piston assembly is spring-loaded in a direction towards the inlet chamber D. In the absence of any pressure, in the chamber D, to counterbalance this spring-loading, one end of the needle valve closes the orifice at F in the connection B to the cut-out valve. On the other hand, if the pressure in the inlet chamber is sufficient to counterbalance the spring-loading, this end of the needle valve is lifted off its seat and the other end is moved towards G to restrict the orifice leading to the connection C and the steering control valve. There is a metering hole in the head of the piston to allow the fluid to pass from the inlet chamber to the chamber E, and thence through the orifice G to the steering control valve. Thus, the piston acts as a flow control valve, since the pressure differential between the inlet chamber D and the spring chamber E, on the other side of the piston, is dependent on the flow through the metering hole in the piston crown.

When the vehicle is travelling along a straight road, the accumulator normally is fully charged and the steering control valve is in the neutral position. In these circumstances, there is no pressure in the pipe line from connection B to the cut-out valve and in the line from the connection C to the steering valve. Therefore, the needle valve is spring-loaded against the seat in the orifice F and the flow from the pump passes through the metering hole in the head of the piston to connection C. Because of the restriction of this flow, there will be a pressure differential between the chambers D and E. When the pressure in chamber D is sufficient to overcome the load of the spring, the piston is displaced and the valve lifted from its seat at F. Then the flow in excess of that through the hole in the piston head passes through connection B to the cut-out valve.

If the steering control valve is operated, a pressure is built up in the continuous flow circuit through connection C.

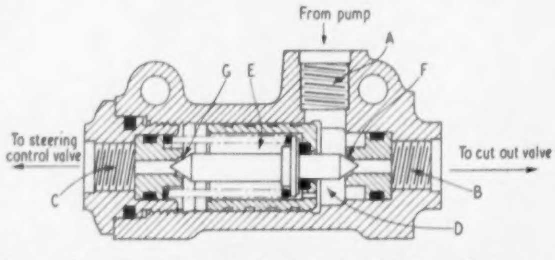
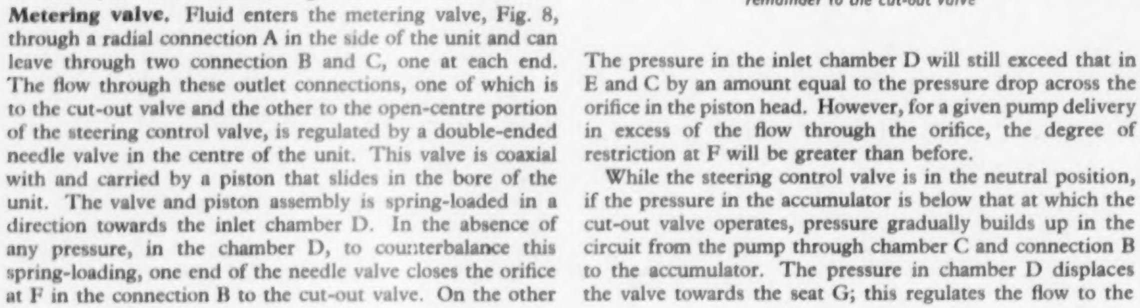


Fig. 8. The metering valve distributes the first 1 gal/min of the pump output to the continuous flow portion of the steering valve and the remainder to the cut-out valve

The pressure in the inlet chamber D will still exceed that in E and C by an amount equal to the pressure drop across the orifice in the piston head. However, for a given pump delivery in excess of the flow through the orifice, the degree of restriction at F will be greater than before.

While the steering control valve is in the neutral position, if the pressure in the accumulator is below that at which the cut-out valve operates, pressure gradually builds up in the circuit from the pump through chamber C and connection B to the accumulator. The pressure in chamber D displaces the valve towards the seat G; this regulates the flow to the

Fig. 9. The accumulator is charged through the cut-out valve on the end of which it is screwed



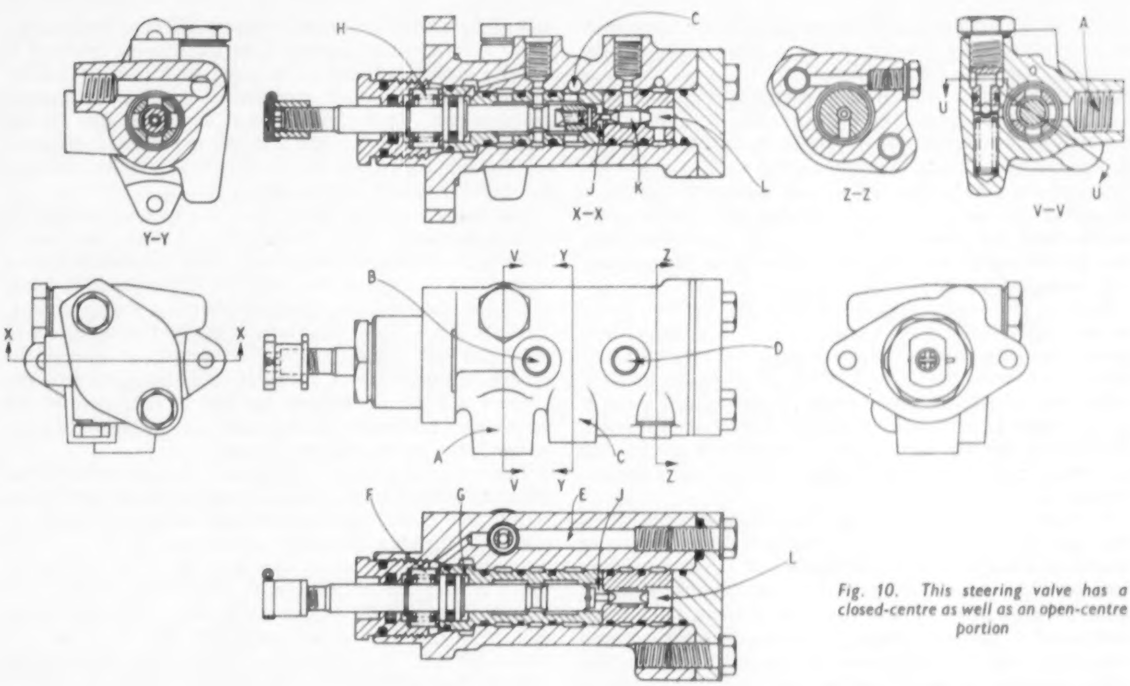


Fig. 10. This steering valve has a closed-centre as well as an open-centre portion

steering control valve until the flow through G is such that the pressure drop across the orifice in the piston crown is the same as that experienced under the conditions previously described. Thus, the flow to the open-centre valve is maintained constant, and the pressure in chamber E is equivalent to the charging pressure less the value of the pressure drop between D and E.

Finally, if the accumulator is being charged and the steering control valve operated simultaneously, while the pressure at the steering valve is equal to the charging pressure, the condition of the metering valve is the same as when the accumulator is charged and the steering control valve not in operation. That is, the flow is throttled at F and the constant pressure drop exists between chambers D and E. There is no pressure drop between chamber E and connection C. If, however, the pressure at the steering valve is less than the charging pressure, the conditions in the valve are the same as when the accumulator is being charged and the steering control valve is in the neutral position. That is, throttling occurs at G and the pressures in the chamber D and the pipe line from B are equal, while the constant drop remains between chambers D and E. The pressure drop between chamber E and the connection C depends upon the pressure at the steering control valve.

Cut-out valve. There are three radial connections to the body of the cut-out valve, Fig. 9. The centre one, B, is the inlet from the pump, while the other two are outlets, one being the return A to the tank and the other the delivery C to the steering valve. An adaptor is screwed into the end of the housing to retain a sleeve D in the bore, and to connect the unit to the accumulator. There are two grooves round the periphery of this sleeve: one is for a seal and the other is to receive the incoming fluid delivered from the pump through port B. Radial holes are drilled through the base of this groove into a central chamber E in the sleeve. One end of this chamber is closed by the sliding valve-seat F, which is spring-loaded in the direction towards the central chamber. A coil spring is employed to effect this spring loading: it is housed in a counterbore in the other end of the sliding seat and bears against a plate in the adaptor. The conical end of a valve spindle G limits the travel of the sliding seat into the central chamber. A collar round the valve spindle seats in the tapered bore of a washer H to close the other end of the central chamber E. The washer is clamped between the sleeve and a distance tube J, and the whole assembly is pulled against a shoulder in the bore of the housing.

A conical spring bears against a flutter plate K, which is free to slide in the bore of the distance tube, and holds the collar on its seat. The other end of this conical spring seats on a washer, which clamps a lip type seal against a retainer ring. This ring also serves as a guide for the valve spindle. Two coil springs, one inside the other, control the valve unit. They are retained between two steel washers, one bearing against a spherical end of the valve spindle and the other against a screw in the end of the housing. This screw provides for adjustment to obtain the correct cut-out pressure; the valve areas control the pressure range.

The operation of the valve is as follows. Oil from the pump passes through connection B to the central chamber E. The pressure in this chamber drives the sliding valve-seat F away from the conical end of the spindle. This allows the oil to flow through the valve into the accumulator. When the cut-out pressure is reached, the pressure built up in the central chamber moves the valve spindle until the collar round it is clear of the valve seat H. Then the flutter plate K is lifted clear of the collar, so that the fluid can escape from the central chamber to the return pipe connection at A. The resultant drop in pressure in the central chamber allows the sliding seat F to move into contact with the conical end of the spindle, and so closes the port to the accumulator. This is known as the *cut-out condition*. If the pressure in the accumulator falls, the sliding seat F moves and the collar round the spindle is gradually lowered on to its seat H; then the flutter plate again comes up against the flange, and the operating cycle begins again. This is known as the *cut-in condition*.

An interesting detail of this unit is the seal round the sliding seat F. This seal comprises an outer ring of rubber carried round another ring of rubber-bonded fabric. These two are housed in a groove in the bore of a sleeve. The inner

ring of fabric gives a long life in service. All the other seals in the unit, except for the lip type component, already described, are plain rubber rings.

Accumulator. The accumulator comprises a cylinder with a cylinder head spigoted into each end, Fig. 9. These heads are retained by caps screwed over the ends of the cylinder. A twin sealing ring assembly is carried in a groove round the spigot of each head. One half of each twin-ring assembly is of rubber and the other is of rubber-bonded fabric. The rubber ring is exposed to the interior of the accumulator, and the other prevents the rubber from being jammed into the clearance between the spigot and the cylinder.

One of the heads, that adjacent to the cut-out valve, is designated the hydraulic head. There is a tapped hole in its centre to receive the adaptor on the cut-out valve. The other is called the air head. This has a Schrader inflation valve screwed into an axial hole in its centre, and a cap is screwed over the boss into which the Schrader valve is fitted. The end of this cap seats on a circular section rubber ring to ensure that, in the event of the Schrader valve leaking, air pressure is not lost.

A piston is housed in the accumulator to separate the oil and the air. It has a triple-washer type seal in a groove round its periphery. The intermediate of the three sealing washers is of rubber and the outer two are of rubber-bonded fabric. The function of these two outer washers is to prevent the rubber from being dragged into the clearance between the piston and the bore when the assembly moves axially in the cylinder. Air is pumped in through the Schrader valve, and this determines the pressure of the delivery from the accumulator. The entry of oil into the other end is regulated by the cut-out valve in the manner already described.

Steering control valve. The steering control valve, Fig. 10, is actuated by the steering wheel shaft through a differential gear. Its essential components are a central spindle, or slide, two sleeves and the housing. One end of the slide is carried in a sleeve that forms the open-centre portion of the valve and the other is in a sleeve forming the closed-centre portion. The whole assembly is in a cast aluminium housing. There are four ports in this housing. The pipe connected to A is from the reservoir; that to B is from the side of the jack adjacent to the larger area of the piston; the pipe connected to the tangential port C is from the three-way connection to the pump and the side of the cylinder adjacent to the smaller area of the piston; the fourth connection D is to the accumulator. A longitudinal passage E in the housing connects C with the chambers F and L. A spring-loaded-ball type relief valve is carried in a hole that breaks diametrically through the passage E. In the event of the pressure in this passage becoming too high, the ball lifts and the excess pressure is relieved into connection A. Another hole is drilled between the chamber G and the connection B.

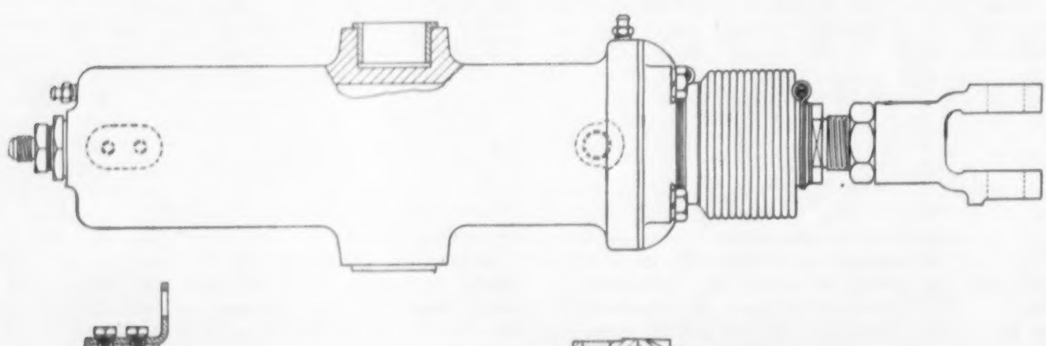
The chambers F and G are separated by a grooved collar formed integrally round the spindle. A two-piece seal is fitted in the groove, the two pieces being rectangular section rings fitted one inside the other. A rubber-bonded fabric ring forms the outer piece, and a rubber ring the inner piece. This seal bears in a counterbore in the end of the sleeve in which the valve spindle slides. The spindle, or slide, of the valve is centralized by a spring H compressed between two washers and located between the end of the sleeve of the open centre portion of the valve and a counterbore in a nut screwed into the end of the housing.

There is a waist round the plunger. It is so arranged that when the valve is in the neutral position, the waist is in line with a hole drilled radially, through the land between two grooves in the bore of the sleeve, to an annular groove round the periphery of the sleeve and in the bore of the housing, which is connected to the port B. Radial holes connect the annular grooves in the bore of the sleeve to two more annular grooves in the housing and round the sleeve, one on each side of the first. One of these two is connected to the port C and the other to the port A. There is also a flat on the spindle to allow oil from the annular grooves connected to C to pass along to a chamber J between the end of this portion of the valve and the extension that forms the closed-centre part of the valve K. The sleeve round the closed-centre portion of the spindle also has an annular groove in its bore and another round its periphery. They are interconnected by radial holes and are in communication with port D.

A conventional steering jack, Fig. 11, is employed. The cylinder is of Meehanite GC. It is cast in one piece and a cover of the same material is spigoted into its open end. This cover also forms the guide for the ram. One of the hydraulic connections is effected by a two-piece adaptor in an axial hole in the closed end of the cylinder and the other is by a single adaptor in a radial hole near the end cover.

The ram is of En 1A. It carries a two-piece, rectangular

Fig. 11. The steering jack is of conventional form, but is unusually compact



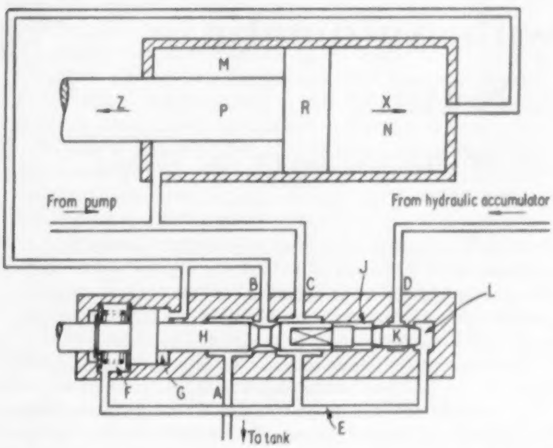


Fig. 12. Diagrammatic illustration showing the principle of operation of the steering valve and jack

section seal, comprising a rubber inner ring surrounded by a rubber-bonded fabric outer ring. Its diameter is approximately 2 in and the bore of the cylinder is about 2$\frac{7}{8}$ in. The ram is counterbored 1$\frac{1}{4}$ in diameter to save weight. An adaptor for a fork-end joint is screwed into its outer end. A rubber gaiter is fitted over the end of the ram and cylinder cover to prevent abrasive matter from getting on to the ram and damaging the seal in the guide. This seal is a rectangular section, rubber ring with a rectangular section, rubber-bonded fabric insert in a counterbore in its outer end.

Principle of operation. A diagrammatic illustration of the steering unit and jack is given in Fig. 12 to show the method of operation of the system. If the load applied to the steering wheel is small, operation is effected manually. When the load is increased until it is sufficient to overcome the spring load that maintains the slide H in the neutral position, hydraulic assistance is obtained.

In the illustration, the slide is in the neutral position. Ports C and B are interconnected and are also in communication with port A to the supply tank. The supply from the pump is connected to the chambers M and N, on both sides of the piston. The connection M is taken directly from the supply line from the pump, while that to N is made through ports C and B in the steering valve. Since the flow from the pump is free to pass directly through the steering valve back to the supply tank, there is only a very slight back-pressure in the system.

The ratio of the areas on each side of the piston R is 2 : 1. Likewise, the ratio of the areas on both sides of the collar, which separates chambers F and G, to the area on the small end of the stem, in chambers J and L, also is 2 : 1. When the slide is moved outwards from the neutral position, that is, to the left, the chamber N is connected by the port B and the waist round the slide to the port A and the supply tank. At the same time, the passage between port C and the supply tank is restricted so that the pressure in chamber M is increased and the piston moves in the direction X. In these circumstances, the pressure in chamber M is communicated by way of the flats to the small end of the slide in chamber J, and it is also transferred through the connection E to the chambers L and F. However, the force which the pressure applies on the side of the collar adjacent to chamber F is in effect halved, because the force on the small end of the slide is acting in the opposite direction; the out-of-balance force, which is the difference between the two, resists the movement of the slide in the outwards direction and provides the necessary feel back to the driver.

When the slide is moved to the right, from the neutral position, the passage of the oil is restricted equally from both B and C to the tank. Therefore, the pressures in the chambers M and N tend to equalize. However, because of the difference between the areas of the two sides of the piston, the force applied to the side adjacent to the chamber N is greater than that applied to the other side of the piston. Therefore, the piston moves in the direction Z and the oil tends to be displaced from chamber M through the control valve into chamber N. Again, the pressure acts on the small end of the slide but it also acts on both sides of the collar, that is, the pressure is equal in chambers F, G, J and L. Because the pressures on each side of the collar on the slide are equal, they cancel out, but the inward movement of the slide is restricted by the pressure acting on its small end; this provides the feel back.

The pressure build-up in the jack is proportional to the amount of load applied to the control valve slide. As a safeguard, a relief valve is incorporated. In the event of the pressure exceeding a predetermined maximum, this valve lifts and allows oil to flow from the passage E back to the tank. When the load on the steering wheel, tending to move the slide in either direction, is released, the hydraulic forces return the slide to its neutral position, where it is retained by the centring spring. The normal self-centring action of the road-wheels returns the piston to the neutral position.

Should the engine-driven pump be operating at low speed, the delivery of oil may be insufficient to keep up with the relative movement demanded by the driver. Consequently, the load applied by the steering wheel exceeds the hydraulic reaction on the slide. In these circumstances, the slide moves further than if the pump delivery were normal. This large movement causes the end of the slide to open the port D, so that the pump supply is supplemented by the flow from the hydraulic accumulator. When the slide is moved outwards, the oil flows along passage E to port C and the chambers M and F. On the other hand, if the slide is moved inwards, the flats on it allow the oil to pass to ports C and B. Each end of the closed-centre portion of the slide is chamfered by machining two flats diagonally opposite to one another on it. This is to give a progressive opening of the port D. Operation of the units when accumulator pressure is applied is the same as with normal pump flow.

INSTITUTION OF MECHANICAL ENGINEERS

April Meetings of the Automobile Division

London

Tuesday, 17th April, 5.30 p.m., at the Institution of Mechanical Engineers, 1 Birdcage Walk, Westminster, S.W.1. Paper: "Front Suspension and Tyre Wear," by V. E. Gough, A.M.I.Mech.E. and G. R. Shearer, G.I.Mech.E.

North-Eastern

Wednesday, 11th April, 6.30 p.m., at the Cleveland Scientific and Technical Institute, Middlesbrough. Paper: "Rocket Propulsion," by Professor A. D. Baxter, M.Eng., M.I.Mech.E.

Wednesday, 18th April, 7.30 p.m., in the Chemistry Lecture Theatre, The University, Leeds. Paper: "Matching a Diesel Engine to Light Road Vehicles," by N. M. F. Vulliamy, M.A., A.M.I.Mech.E.

Western

Thursday, 26th April, 6.45 p.m., in the Royal Hotel, Bristol. Paper: "Ball and Roller Bearing Development," by M. J. Knaggs, M.I.Mech.E.

Boring Machine with Automatic Co-ordinate Setting

Kearns No. 0 Planer Table Type with British Thomson-Houston Co. Ltd. Control

SOME two years ago the British Thomson-Houston Co. Ltd., commenced the development of automatic co-ordinate-setting for boring machines; past experience in the manufacture of certain of the Company's own products, such as gear boxes, had led to the conviction that production costs could be materially reduced by the elimination of the many and often costly jigs heretofore associated with such manufacture. Appreciable time saving would also result since it is common experience that the design and manufacture of special jigs may delay the start of production by many months.

The first commercial installation of an automatic co-ordinate setter was completed several months ago, for the Leicester Factory of the British United Shoe Machinery Co. Ltd. The work has been successfully carried out in close co-operation with H. W. Kearns & Co. Ltd., the automatic controls being applied to a Kearns No. 0 planer table type horizontal boring machine. A general view of this installation appears in Fig. 1.

Essentially, the co-ordinate setter comprises servo-mechanisms operating the horizontal and vertical slides of the machine which have traverses of 57 in and 42 in respectively. The slides can be set to any position by setting up the co-ordinates on dials, which are to be seen on the face of the control desk in Figs. 1 and 2. Six dials and clearly displayed figures are provided for each of the two ordinates, to set up any required displacement from a predetermined datum. The "dial-in" feature is appropriate to very short run production and tool-room class of work generally and results in marked time saving as the operator is relieved of the duty of reading and adjusting to finely graduated scales, or handling of length-bars.

For longer runs the slides can be set up by a card reader also on the operator's control desk, and shown in more detail in Fig. 2. One punched card per hole centre has been adopted, which enables operator instructions to be added where appropriate, thus a deck of cards must be prepared per workpiece. Automatic clamping of the slides is provided when the desired co-ordinate position is reached.

The blue-print (which may not be required on the factory floor so far as the boring operations are concerned) will show dimensions with respect to two datum lines convenient to the particular workpiece. To simplify setting up procedures, the co-ordinate setter includes means for changing quickly the datum of measurement for each traverse. The wide speed range servo-mechanisms necessary for co-ordinate setting provide a convenient feed drive for milling operations, for which suitable controls are provided.

The machine tool is basically a normal Kearns horizontal borer with the addition of the power servos already mentioned and a built-in measuring system for automatic control. Certain special provisions have been made in the mechanical design. They are discussed later.

Principles of operation

The card reader unit serves to shift the hand setting dials, thereby giving a check, if necessary, on the accuracy of card reading. Identical servo-systems are used for both traverses and it is therefore sufficient to describe operation from the dial shafts on the operator's desk, to the control of one motion.

Referring to Fig. 3, the electrical measuring system on the machine tool table comprises a rigid measuring bar accurately divided into one inch units by holes spaced 1 in apart along its length. An electromagnetic sensing head, mounted on the bed of the machine tool co-operates with the bar and provides an electrical misalignment signal to the control system. The electromagnetic unit is capable of being shifted by a micrometer screw and an accurate instrument

Fig. 1. Kearns No. 0 planer table type horizontal boring machine with British Thomson-Houston controls for automatic co-ordinate setting

servo through any displacement up to one inch. Thus the measuring bar may be regarded as providing accurate measurement of the integral inches part of a required co-ordinate shift, while the decimal part is accommodated by accurately controlled shift of the sensing head.

In more detail the controlling action is as follows, described as a sequence, though in practice certain motions take place simultaneously. It will be assumed that the required co-ordinate has been set up on the six dials. Through suitable gearing the "input" synchros S_1 S_2 S_3 S_4 are rotated, and give misalignment signals in co-operation with the corresponding "output" synchros T_1 T_2 T_3 T_4 respectively.

The decimal dimension is defined by shaft rotation of S_2 S_3 and S_4, which causes the servo-amplifier A to operate motor M_1 until S_2-T_2, S_3-T_3, S_4-T_4 are in alignment. High quality instrument gearing and an accurate micrometer screw shift the electromagnetic unit through the required decimal dimension. The integral part of the desired co-ordinate (with a contribution from the decimal part) gives a rotation of synchro S_1 which is interconnected with synchro T_1 geared to the leadscrew. A misalignment signal from S_1-T_1 controls servo-amplifier C and via the motor M_2 brings the table to within about 0·2 in of the desired position, the traverse speed being maintained at about 120 in per minute until the last inch or so of travel is reached, after which the speed is progressively reduced. Control of M_2 is now transferred (via servo-amplifier B) to the electromagnetic head. The control signal from the latter drives M_2 until the poles of the magnetic head are aligned opposite the nearest hole in the bar, under which conditions the error signal from the magnetic head becomes zero.

During the approach to alignment under the control of the electromagnetic head, a temporary misalignment signal is injected into amplifier B, so that the table travels to a "false alignment" position, approximately 0·020 in from true alignment. The temporary signal is then automatically removed and thus the final approach to alignment is always from the same direction. The error signal from the magnetic head is proportional to displacement from the desired position, and reverses in phase for an error in the opposite direction. This permits the final approach to alignment to be made under conditions of controlled velocity and retardation of the table, so that the manner of stopping is predetermined by the electronic circuits, and not by extraneous conditions such as viscosity of lubricants, table loading, etc. After the setting of the digit dials—by hand or card—the automatic setting of both co-ordinates on the machine tool is initiated by push-buttons, and the sequence ends by the automatic clamping of both motions.

Fig. 2. The control desk, which incorporates a card reader

Detail of the measuring system

The measuring bar is of heavy construction in a special steel and carries the "inch units" which are identical blocks with a ¾ in dia. hole in the face. In order to present a smooth face the holes are filled with brass inserts. The bar is set up in a temperature controlled measuring room so that the reference holes are 1·000 ± 0·0002 in apart. A final screwdriver adjustment is available, which through the medium

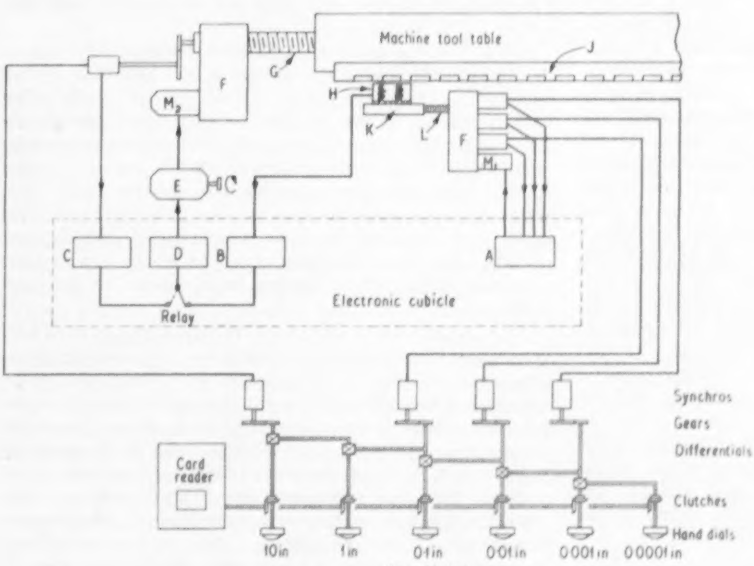


Fig. 3. Schematic arrangement of the control system

A, B, C, *servo amplifiers* **D** *field control amplifier* **E** *generator* **F** *gearbox* **G** *lead screw* **H** *electromagnetic head* **J** *measuring bar* **K** *slide* **L** *micrometer screw* **M_1** *motor* **M_2** *motor*

of an asymmetrical steel slug in the bar allows the effective magnetic position of each hole to be shifted up to $\pm 0{\cdot}0005$ in. The final adjustment is preferably left until the bar is in position on the machine tool.

Essentially, the electromagnetic head is a differential arrangement of two transformers, the magnetic circuits of which are completed by that part of the measuring bar which faces the head. The construction of the head is symmetrical so that it is free from changes caused by temperature, supply voltage and frequency variations, and stray magnetic fields. The gap between the magnetic head and bar is not critical. Such is the sensitivity of the head that it is capable of delivering a sufficient voltage to operate the servos with 20 microinches misalignment from the magnetic centre of one of the reference holes in the bar. The head carries oiled felt pad wipers which clean the face of the measuring bar.

As previously stated, the sensing unit in the head is shifted by the decimal part of the co-ordinate desired, and accordingly it is carried on a short accurately made slide, parallel with the measuring bar. A high accuracy electronic servo effects the positioning through the medium of a gear box and micrometer screw. As shown in Fig. 3, coarse, fine, and very fine synchro data units are used to attain high accuracy. While reliance is placed on the accuracy of a micrometer screw to shift the electromagnetic head, it must be remarked that the only force on the screw is that to move a mass of a few ounces in carefully made slides.

Operator's control desk

The control desk (Fig. 2) may be located at the most convenient position to suit the machine tool operator, since connection to the rest of the system is by the electrical control wiring only. Appreciable space on the desk is allocated to the digit set up dials, to give clearly displayed figures and conveniently sized and disposed set up knobs. Detent action on the dial shafts gives positive location for each of the ten decimal positions of each dial.

Referring to Fig. 3, it will be seen that the synchros S_1, S_2, etc., are not operated directly by the dials, but through differential gears and other gearing of appropriately chosen ratios. The differentials serve to add one-tenth of the rotation of any dial to that of the shaft behind the adjacent dial on its left-hand side. Briefly, this is necessary because of the following considerations:—

(a) In the coarse, fine and very fine data transmission between the desk and the micrometer servo, there is a fixed relationship between the rotors of T_2, T_3 and T_4 through a normal gear train. The same apparent relationship must, therefore, hold between the shafts of S_2, S_3 and S_4 in order that alignment S_2 to T_2, S_3 to T_3 and S_4 to T_4 may take place simultaneously and unambiguously, wherever the dials are set. It would not be satisfactory to gear the dials together directly; with such an arrangement the right-hand dial would need to make a thousand revolutions for every inch change of setting. This would neither be convenient nor speedy. It is preferable that, to the operator, the dials should appear to be independent.

(b) Differential coupling is also used to the left of the decimal point. This is to ensure that no ambiguity arises if the input dials are changed from say, 12·0000 to 12·9999. This would cause the electromagnetic head to be moved very nearly into alignment with the 13th unit on the measuring bar. It must not, however, be aligned with this unit, but with the 12th. Therefore, the synchro S_1 is rotated by an amount which corresponds approximately to 0·9999 in and through the main servo motor M_2 brings the table nearly to the correct position as described previously.

Card Reader. This is to be seen on the left-hand side of the desk in Fig. 2. Standard size business machine cards are used, but made of a material which is impervious to oil. They can be prepared for use by means of a simple hand punch.

In operation, a card is taken from a stack and placed on the carriage. A "start" push button is pressed which causes the carriage with the card on it to be drawn into the reader. Simultaneously, the dials are automatically returned to their zero positions. The carriage then reverses its direction of movement and brush contacts are lowered on to the card. As the card is returned to its start position, the dials are rotated in unison. The brushes can complete electric circuits through the holes in the card and when any one brush makes contact, the appropriate dial is disengaged from the driving mechanism and is left accurately positioned by means of a detent wheel and spring loaded arm.

Features of the machine tool

The machine is constructed on the well known Kearns unit principle and consists of a main bed 10 ft 0 in long, carrying a table 3 ft 0 in × 6 ft 0 in. This main table, on which is mounted a cellular constructed revolving table 3 ft 0 in square, has a total transverse traverse of 4 ft 9 in. In view of the length of the main bed, the table is fully supported throughout the full length of this traverse.

Built into the main table is an easy revolving mechanism for lifting the revolving table, to reduce the effort required for rotation. At both sides and at right angles to the main bed are auxiliary beds each 4 ft 0 in wide across the ways and carrying the upright and boring stay bases respectively. These bases can be traversed longitudinally a distance of 2 ft 0 in on their beds to give a total distance between the spindle nose and boring stay of 7 ft 6 in.

In the case of the upright base, which carries the upright and spindle slide, this can be traversed rapidly by a built-in stator and rotor unit in addition to which a full range of sixteen reversible power feeds is available. A well proportioned upright carries the spindle slide in which is incorporated the change speed and feed mechanism for the longitudinal traverse of the spindle and upright base. The travelling spindle is of nitrided steel super finished and bored with a No. 5 Morse Taper. It slides in a nitrided cast iron bush, within a sleeve of forged steel, which rotates in precision ball and roller bearings.

A range of sixteen reversible speeds is available to the 3 in diameter spindle and these are selected by only two levers.

A 5 h.p. stator and rotor unit is mounted in the base of the upright. It drives the change speed gear box in the spindle slide through a constant speed vertical shaft. The feed mechanism to the longitudinal traverses of the spindle and upright base embodies a patented arrangement whereby two complete ranges are available. One is driven from the spindle sleeve and gives eight feeds in cuts per inch. The other is driven from the first motion drive shaft and gives eight feeds, independent of the spindle speed, in inches per minute. The main drive motor is controlled by an automatic contactor direct-on-line starting panel housed in the back of the upright.

In designing this machine, H. W. Kearns have been very conscious of the problems involved, not only of utilizing the accuracy available in the electronic co-ordinate setting system, but also of maintaining it throughout the life of the machine. In an attempt to achieve these objects the transverse movement of the main table is obtained by mounting the gear box direct on the end of the main bed, thus giving a direct drive via a constant length shaft and two large diameter coupled worms, to a segmental phosphor bronze nut, attached to the main table. This gear box, in addition to providing the drive for automatic positioning, gives an

infinitely variable range of feeds from $\frac{1}{2}$ to 10 in per minute, also rapid traverse at a rate of 120 in per minute.

Of vital importance is the type of lubrication system, its application and the lubricant used. The table lubrication is provided by a motor driven oil pump with independent feed regulators to the various points. A number of large sectioned interconnected oil grooves, at right angles to the line of travel, are machined in the main table. The motor driven oil pump is interconnected with the control pendant and operates automatically whenever the table is traversed.

The vertical movement of the spindle slide is also directly under the control of a gear box which is mounted on the top of the upright and directly coupled to a large diameter vertical screw. This box provides the drive for automatic positioning, together with the range of feeds and rapid traverse motion similar to the main table. As in the case of the main table, exceptionally long narrow guides are used on the spindle slide.

The control pendant carries ten push buttons. Three of these control the main spindle motor, giving start/forward, one each on the transverse movement of the table and vertical adjustment of the boring stay bearing.

To ensure that no distortion takes place on the main sliding surfaces, the hydraulic locks operate through a friction material with independent strips attached to the main casting. The vertical adjustment of the spindle slide and boring stay bearing are synchronized mechanically, but if required, the boring stay bearing can be realigned vertically through a worm wheel mechanism operating on the screw nut.

The accuracy required for the installation described here is $\pm 0{\cdot}0005$ in, but $\pm 0{\cdot}0002$ in is achieved in practice. By using very accurate micrometer screws for positioning the detecting heads, and by taking advantage of the facility for fine adjustment of the 1 in units on the measuring bar, the equipment is capable of $\pm 0{\cdot}0001$ in. The measuring bars are set at 68 deg F, and have the same temperature coefficient as cast iron. Consequently, variations of shop temperature do not produce discernible errors when working on cast iron.

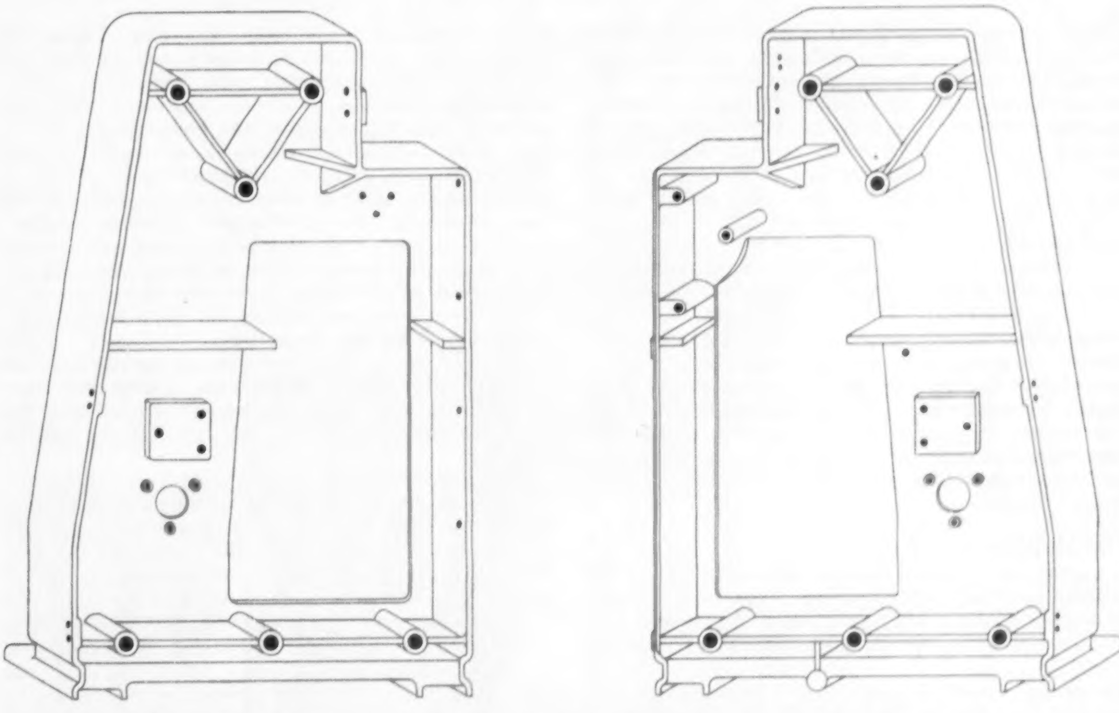


Fig. 4. The use of automatic co-ordinate setting virtually halved the machining time on these machine frames

start/reverse and stop, an electro dynamic braking system being used for stopping the spindle. Three further buttons control the inch/forward, inch/reverse to transverse movement of the table and the start of automatic positioning. Three buttons are also provided to give a similar control to the vertical movement of the spindle slide. The remaining push button stops the spindle slide and table movement.

In order to ensure the holding of a slide which has reached the required position, hydraulic clamps automatically operate on the spindle slide, table and boring stay bearing. The hydraulic clamping unit is carried in a steel cabinet alongside the machine. Solenoid operated valves control the oil circuit which operates the hydraulic cylinders. Maximum clamping efficiency is obtained by the use of a wedge lined and bushed by plates of P.T.F.E. material. Two of these clamps are provided on the spindle slide and

A very considerable saving in labour time can be obtained through the use of this control system. For example, the right-hand frame shown in Fig. 4 has six holes drilled and counterbored, nine holes drilled and tapped and 11 holes drilled. The total time for marking out and drilling, before the introduction of automatic positioning, was 4 hrs 34 mins, whereas with automatic positioning the total time is reduced to 2 hrs 17 mins. On the left-hand frame nine holes are drilled and counterbored, seven are drilled and tapped and eight drilled and spotfaced. On this frame the total time has been reduced from 4 hrs 47 mins to 2 hrs 34 mins. A second Kearns No. 0 planer table type horizontal boring machine has been constructed with the British Thomson-Houston automatic co-ordinate setting system and will be shown at the forthcoming International Machine Tool Exhibition in London.

The new Ford Zephyr was among the British exhibits that attracted considerable attention at Geneva. It represents a marked advance in design in that the standard of comfort offered is higher than ever before in quantity-produced cars of this class

The Geneva Show

A Survey of Features of Technical Interest Among the Quantity-Produced Private Cars

AMONG the British exhibits at the Geneva Show, the new Ford models attracted considerable attention, partly because they had only been introduced a few weeks earlier, but also because they offer a higher standard of comfort than has previously been offered in cars of this type. In the past year, the Ford Motor Co. have sold in Switzerland more vehicles than any other British manufacturer, and with the new Consul, Zephyr and Zodiac models shortly going into production, no doubt they will be even more successful next year.

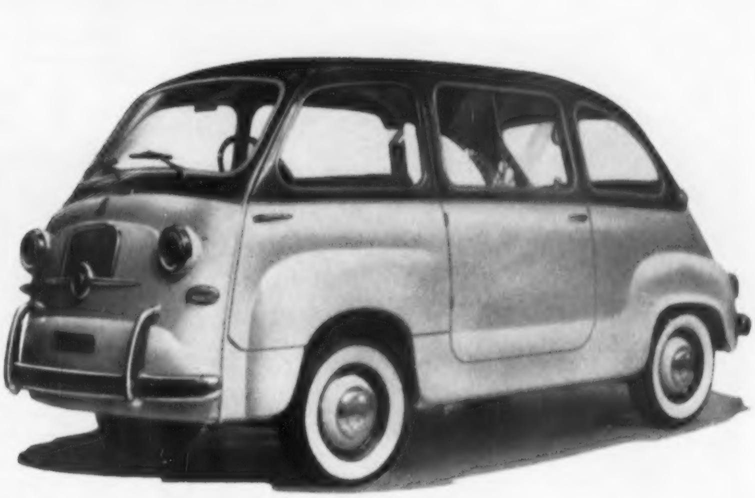
Another new model exhibited for the first time at Geneva is the Renault Dauphine, which is described elsewhere in this issue. The Fiat Multipla, also exhibited at the Brussels Show earlier this year, attracted considerable attention at Geneva. It is, perhaps, significant that all these manufacturers have introduced cars that are larger than their earlier models. The tendency for successive models to be bigger than the ones they replace was also apparent in the period between the last two wars. A good example of this trend was the development of the Austin Seven between the early 1920's and 1939.

Fiat Multipla

A number of European manufacturers now offer six-seater vehicles powered by small engines. The latest design to be introduced is the Fiat 600 Multipla. Undoubtedly it is also the best, both as a sound engineering product and from the wider points of view of owners in general. The vehicle is offered with either one bench type seat at the front and four bucket seats mounted in pairs behind it, or, alternatively, with two bench type seats, one behind the other, and with extra luggage space. In both versions, all the seats except the front one can be folded down to provide for the carriage of goods instead of passengers. When the four bucket type seats are fitted, any of them can be folded down separately. The cushions of the intermediate pair fold forwards against the back of the bench type seat and their squabs fold forward on to the floor. Also, the two rear seat cushions fold forwards, but they turn upside down on the floor, while their squabs fall down behind them. The result is a flat floor for the carriage of luggage. If two bench type seats are fitted, the cushion of the rear one folds forwards and is stowed vertically against the back of the front one, while its squab falls forward and forms an extension of the rear part of the luggage platform.

A load of 770 lb can be carried, in addition to the driver, and the maximum area of the loading platform is about 19 ft^2. When the bench type seats are fitted, the interior dimensions are as follows: from the dash to the front seat squab, measured horizontally, 28¼ in; between the two seat squabs, measured horizontally at waist level, 27½ in; horizontal distance between the top of the engine compartment and the back of the rear seat squab, 21 in. From the centre

The Fiat Multipla can be supplied with four separate seats behind the front bench type seat, as shown in this illustration, or with only two bench type seats to give extra luggage space at the rear. When the four separate seats are fitted, any of them can be folded down separately to provide space for luggage; in the illustration on the left they are all folded down



Convention has been ignored in the design of the Fiat Multipla and the result is not only a sound engineering product but also a serviceable vehicle that will have great appeal in the home and export markets for which it is intended

of the floor to the roof the distance is 51 in and the bench seat cushions are each 48 in wide.

This vehicle has a wheelbase of 6 ft 6$\frac{3}{4}$ in. At the front, the track is 3 ft 7$\frac{29}{32}$ in and at the rear it is 3 ft 9$\frac{5}{16}$ in. A remarkable feature of the vehicle is that although it has accommodation for six people, its overall length is only 11 ft 7$\frac{1}{4}$ in, and its width is 4 ft 9 in. The overall height is 5 ft, while the ground clearance is 5·9 in. A turning circle of 29 ft diameter is obtained.

Illustration showing how the rear bench type seat in the Fiat Multipla is folded to make space for the carriage of goods

Adjustment of the squab angle is provided for by a link at the base and a locking plate at the top on each side

Figures for the weight distribution are not available, but undoubtedly it is better than that of the four-seater car version of the 600, since the driver and front passenger sit directly over the front suspension. In fact, the front seat rests on the wheel arches. An unusual feature of the vehicle is the fact that the spare wheel is carried under the dash in front of the seat beside the driver. However, this does not cause any discomfort to the passenger, because there is space for his feet underneath the spare wheel. Another unusual feature of the vehicle is that the steering box is above the floor and the shaft, on the lower end of which the drop arm is mounted, is extended between the driver's legs and through the floor. The lower end of this shaft is supported by a bearing mounted under the floor.

Although the seats are not adjustable, the driving position is high and, therefore, comfortable, and gives an excellent range of vision. A peg projecting sideways from each end of the top of the squab seats in any one of three U-shaped slots in the upper edge of a bracket attached to the intermediate pillar. The lower portion of the squab is connected by a link on each side to the frame that carries the cushion. One end of this link is pivoted to the frame and the other to the squab. This unusual arrangement has been adopted so that the squab can be lifted to move the pegs from one slot to another to alter the squab angle. No doubt the links could have been dispensed with but for the fact that almost any other arrangement that might have been adopted would have been liable to rattle or would have been more expensive. Under the front seats, the floor is raised to clear the suspension units and forms a ramp for the feet of the passengers in the rear seats. The floor is covered with black rubber, beneath which is bitumen-impregnated underfelt.

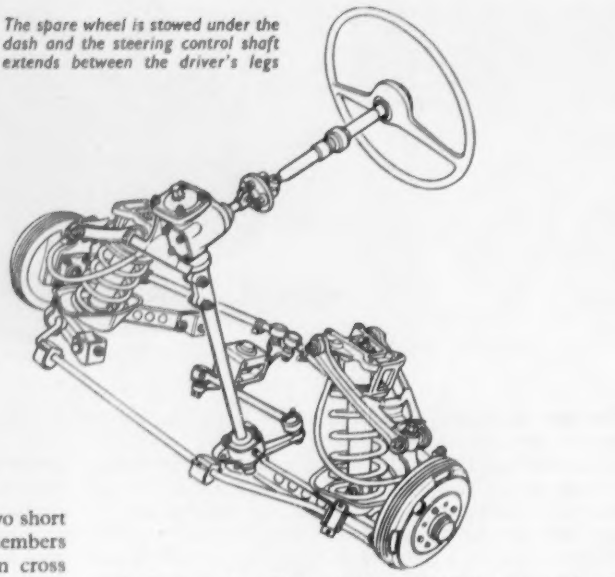
The two doors on each side are hinged on the centre pillar. Their hinges are not concealed; each comprises a single blade bolted to the pillar and two other blades secured, one to each door. A drop glass is fitted to the front door and the rear doors are each equipped with two horizontally-sliding glass panes. This arrangement is unusual: almost all vehicles with horizontally-sliding windows have one fixed and one sliding glass and so there inevitably is a small overlap between the two, which is difficult to clean. The rear quarter lights are fixed. Both the screen and the rear light are curved. Polished aluminium is employed for all the bright metal parts both inside and outside the vehicle, except the bumpers, which are chromium plated.

So far as the mechanical components are concerned, the vehicle is practically identical with the four-seater car version of the Fiat 600, which was fully described in the October and November, 1955, issues of *Automobile Engineer*. However, in view of the extra weight on the front axle, the front suspension units of the 1100 model are employed. This is a coil spring and double transverse wishbone type layout with telescopic shock absorbers carried coaxially with the springs. An anti-roll bar is also incorporated. A final drive ratio of 7:45 has been adopted. In the Multipla, the petrol tank is mounted at the back of the car and has a capacity of 6$\frac{1}{4}$ gallons.

The vehicle is of chassisless construction, and at the rear end is similar to the four-seater car. The main longitudinal members are two deep-section sills and a central backbone component. At the front, the suspension is carried on the

Because the load on the front wheels of the Multipla is appreciably greater than that on those of the Fiat 600 car, it is equipped with the sturdy front suspension of the 1100 model

The spare wheel is stowed under the dash and the steering control shaft extends between the driver's legs



ends of a cross member, which is bolted on top of two short longitudinal members, one on each side. These members are supported at their front ends by a box section cross member under the toe board, and at their rear ends by a similar cross member under the floor behind the front seat.

B.M.W.

Three new vehicles that are exceptionally well styled have recently been introduced by B.M.W. Two are the 503 fixed and folding head coupés and the third is the 507 sports touring car with a hard top. Both are powered by the 3·2 litre V8 engine, which now develops 150 b.h.p. at 4,800 r.p.m. The maximum torque is 163 lb-ft and it does not fall appreciably over the range of 2,000-2,800 r.p.m. This is a good performance for a sports car engine. The chassis of the three models are based on the well known sturdy frame, comprising box and tubular section members, that has been used for many years by this firm.

In the 507, lateral location of the rear suspension is now effected by a Panhard rod. Light alloy brake drums, with shrunk-in grey cast iron inserts, are fitted. A five-speed gearbox is employed, the gear ratios being: 3·09:1, 2·023:1, 1·5:1, 1·205:1, 1:1, and the reverse gear ratio is 2·205:1. The normal axle ratio is 3·7:1, but the car can be supplied with ratios of 3·42:1, or 3·9:1. The tyre size is 6·00-16,

The B.M.W. 507 is now available with a plastics hard top

racing. A curb weight of about 2,579 lb is quoted. The wheelbase is 8 ft 1½ in and the track 4 ft 8¾ in at the front and 4 ft 8 in at the rear. So far as overall dimensions are concerned, the vehicle is 14 ft 5 in long, 5 ft 5 in wide and 4 ft 1½ in high in the laden condition without the hard top, which is of glass reinforced plastics and can be removed easily.

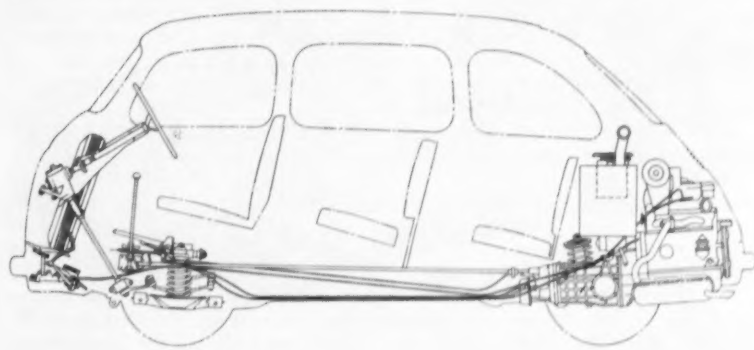
The 503 has a four-speed gearbox with ratios of 3·54:1, 2·202:1, 1·395:1, 1:1, and the reverse gear ratio is 5·03:1. In standard form, the axle ratio is 3·9:1, but the vehicle can be supplied with a ratio of 3·42:1. The tyres are of the 6·40-16 racing type. A curb weight of 3,219 lb is quoted. The wheelbase is 9 ft 3¼ in; the track at the front is 4 ft 7 in and at the rear 4 ft 8 in. This vehicle has an overall length of 15 ft 6½ in, its width is 5 ft 7 in. In the laden condition, its height is 4 ft 7 in.

Much of the body equipment is the same for all three models, despite the fact that the styling is completely different. In the 503 models, the windows and the folding head are hydro-electrically actuated. A set of master switches is fitted on the door adjacent to the driver and a separate switch is fitted on each of the other doors for operation by the passengers. At the rear, the boot lid is exceptionally well balanced by torsion bar springs. The rate of these springs has been chosen so that the lid lifts by itself immediately the catch is released, but by the time it reaches the fully open position, it is only just balanced and, therefore, its movement is gentle. Two torsion bars are employed, one for each hinge. Each end is bent at right-angles to form the torque arms. One arm bears under the hinge and the other bears on the wheel arch on the opposite side of the vehicle. The spare wheel and petrol tank are housed side-by-side under the floor. One side of the petrol tank is shaped to fit round part of the circumference of the wheel so that the maximum possible fuel capacity is obtained without sacrifice of luggage capacity.

The bonnet line is exceptionally long and is made to appear even longer by the forward extension of the wings to house the head lamps. Another feature that accentuates the length is a chromium plated strip on each side, extending from a point just above the level of the centre of

A three-cylinder two-stroke engine is employed in the Eisenacher. Despite the fact that this engine drives the front wheels, the bonnet is not unduly long

the head lamp almost to the rear end of the vehicle, where it is turned upwards. An open scuttle vent, over which is fitted an expanded metal mesh held down by a chromium plated bezel, is incorporated. Any water that enters is trapped in a drain channel and led away. This type of arrangement is becoming increasingly popular on American as well as Continental cars. Doubtless it is less expensive than using a hood or a lid, since some form of wire mesh must, in any case, be used to keep out insects, which hoods tend to trap.



General arrangement of the Fiat Multipla. The bench type seat for the driver and front passenger is almost directly over the front wheels, so the weight distribution is good

The whole of the interior of the vehicle, that is, both the side panels and the seats, are trimmed in hide. Large, bucket type seats are installed in the front. They are well upholstered and extremely comfortable. The seats are adjustable in the fore and aft directions and the squab angle can be changed at will. At the rear, a rather small bench type seat for two people is installed. Considerable thought has been devoted to the styling of the interior. Not only does each door, when open, present a pleasing picture, but also when closed blends into the general lines of the interior. Emphasis is on horizontal features. The dash is not very deep and the instrument faces are of rectangular form and their width is much greater than their depth. The horizontal lines are continued by the arm rests on each door. A noteworthy feature is that signalling by means of headlamps can be done not only by the conventional foot-operated switch, but also by a control resembling a horn button in the centre of the steering wheel hub. A more or less conventional horn ring is employed. The provision of a convenient means of signalling by headlamps is important

Left: Horizontal features are accentuated on the facia of the latest version of the B.M.W. 503 model. Right: The trim of the door has been styled in conformity with the remainder of the interior and also to present a pleasing appearance when open. In this illustration, one of the pockets is open to show its large capacity

A noteworthy feature of the Borgward Isabella shooting brake is its good all-round visibility. Many of the body panels and components are common to both this and the standard models

to Continental drivers, who use this method of signalling a great deal at night.

Eisenacher

There are one or two details of interest on the Eisenacher vehicle. This car is powered by a three-cylinder, two-stroke engine, mounted forward of the front suspension. The radiator is behind the engine. This arrangement, together with the employment of the three- instead of a four-cylinder engine, has made it possible to keep the bonnet length to reasonable proportions, despite the fact that the vehicle has front-wheel drive.

The engine has a bore of 70 mm and a stroke of 78 mm. Its swept volume is 900 cm^3 and its compression ratio is between 6·6:1 and 6·8:1. This power unit is said to develop 37 b.h.p. at 4,000 r.p.m. The wheelbase is 8 ft 0½ in, and the track is 3 ft 10·9 in at the front and 4 ft 1·6 in at the rear. The overall dimensions of the vehicle are: length 14 ft, width 5 ft 1·8 in, and height 4 ft 10 in. A weight of 2,400 lb is quoted.

An unusual feature of the vehicle is that two adjustable slat type blinds are incorporated to regulate the flow of air through the radiator. One is immediately behind the grille and the other is behind the lower portion of the fin and tube radiator. The front blind controls the flow of air to the radiator, while the rear one regulates the interior heating system. Air for this system is taken through a duct behind the upper portion of the radiator core. This portion of the core has fins at half the pitch of those in the lower portion. The temperature of the water, and therefore of the air supplied to the interior of the car, can be increased by closing the slats behind the radiator, and the air flow can be increased by opening those behind the grille. In each position, the slats are fitted horizontally in a transverse vertical plane between two vertical pillar assemblies. At each side, the slats are attached to fixed vertical pillars, in such a way that they can rotate about their major axes. Also, at one side, each slat is attached to a vertical rod that is parallel to the fixed pillar. Control is effected by means of a Bowden cable, which raises or lowers this rod, the ends of the slats acting like parallel links between the rod and the pillar.

Since a thermo-siphon cooling system is employed, a large radiator is necessary. Its dimensions are 19¼ in wide × 11 in deep × 3 in thick. The top portion, which forms the heater element, is 3¾ in deep. A six-bladed cast aluminium fan, only 10 in diameter, is employed; it is driven by a shaft carried in a housing cast integrally on the aluminium alloy cylinder head.

On the earlier models, a more or less conventional contact breaker and distributor unit was driven by a vertical spindle from the front end of the crankshaft, but the latest version of this engine has a simple contact breaker only, mounted directly on the end of the shaft. This contact breaker is

Left: The driver sits in the centre at the front end of the Viberti Golden Dolphin but, because of the tapered nose of the vehicle, he has an unobstructed range of vision. A television screen for the passengers is mounted on the pillar behind his seat. Right: There are two entrances to the Golden Dolphin, one on each side, both are below the waist rail, just behind the control platform

used in conjunction with a unit comprising three coils, housed together in a rectangular box mounted on the wing valance panel. This arrangement is less expensive than the earlier one because the drive shaft and gearing have been eliminated.

A free-wheel is incorporated and is controlled by a lever under the dash. In the gearbox, the selector rods are one above the other on the right-hand side. They are controlled by a steering column mounted, gear-shift lever. Axial motion of the control rod parallel to the steering column actuates a cranked cross shaft on the dash, which effects the vertical shift of the striker lever to select one or other of the three rods. Striking is effected by the rotary motion of the lever on the column. The motion is transmitted to another lever at the lower end of the control rod, which is connected to a transverse link in front of the dash. This link transmits the motion to a lever on the end of the vertical spindle that carries the striker lever.

The steering gear is of the rack and pinion type. Transverse leaf springs are employed for both the front and rear suspension units. At the front, the ends of the spring form the upper links; the lower links are of the conventional wishbone type. At the rear, a light box section axle is employed. It is located by a trailing link on each side.

To prevent theft of components and equipment, some cars are so arranged that the boot and bonnet catches can be released only from inside the car. Eisenacher have gone further than this by providing in the boot a catch to lock the flap over the petrol filler cap. This is better than having the filler neck in the boot, since it avoids the danger of petrol being spilled inside. The knob for releasing the boot lid is mounted on the heelboard and that for the bonnet lid is under the dash. Pull-out lever type door handles are employed but they are almost flush against the panels so that there is little danger of their being broken by passing vehicles.

Of all the vehicles with glass-reinforced plastics body panels, the Chevrolet Corvette is undoubtedly the most advanced in design

An unconventional feature of the layout of the Borgward Isabella is that its dash panel is vertical and there is not a toe-board ramp

Borgward and Goliath

Two vehicles that are similar in appearance, but which, in fact, differ considerably in detail, are the Borgward Isabella and the Goliath Juwel. The Borgward Isabella is powered by a four-cylinder four-stroke engine with a bore of 75 mm and a stroke of 84·5 mm, giving a swept volume of 1,493 cm^3. The compression ratio is 8·2:1 and the power output 75 b.h.p. A four-speed gearbox is employed. The ratios are: 3·86:1, 2·15:1, 1·36:1, 1:1, and the reverse ratio is 4·06:1. An axle ratio of 3·9:1 has been adopted.

At the front of the vehicle, the bonnet lid is balanced by torsion bar springs, one fitted to each hinge. The arrangement of the torsion bar is different from that in the B.M.W. vehicles in that the end of the spring under the hinge is shaped like a single-throw crankshaft and is carried between two lugs with holes punched in them to form the bearings for the crank. A short connecting rod is interposed between the crank and the hinge. The other end of each bar is turned through 90 deg and attached to the vehicle structure. Similar torsion bars are employed at the front to balance the boot lid.

This vehicle has an exceptionally sturdy front end structure. The wheel arch valance panel extends straight forward from the dash. Its lower edge is flanged inwards. Above this flange, it extends vertically to a point a few inches below the bonnet opening and then is bent at a right angle outwards and then flanged vertically up again, to receive the bolted-on wing panel. There are two longitudinal members on each side. One is formed by a panel, which is spot welded in the angle between the lower flange and the vertical wall of the valance, to form a box section. The other is a similarly shaped panel, forming a box section in the angle between the vertical portion of the panel and the horizontal portion below the bonnet opening. There are two radiators for the heater. They are in the front ends of the upper longitudinal members, which form the ducts to take the hot air to the interior of the car.

An unusual feature of the vehicle is that the dash panel is vertical and there is no toeboard ramp. Most of the other features of the car are conventional. The squab angle of the two front seats can be adjusted, as also can their fore and aft position. This car, like several of the other European makes and nearly all the American ones, has an electric cigar lighter on the dash facia.

The overall dimensions of the vehicle are: length 14 ft 5 in; breadth 5 ft 7 in; height, laden, 4 ft 9¼ in. A wheelbase of 8 ft 6 in has been adopted and the track is 4 ft 4½ in at the front and 4 ft 5½ in at the rear. The vehicle weighs 2,200 lb empty. With a shooting brake body, it weighs 2,450 lb. The overall length of this body is the same as that of the standard one and the loading space behind the front seats is 6 ft 2 in long × 3 ft 4½ in wide between the wheel arches × 3 ft high. Between the door pillars at the rear end, the width is 3 ft 7 in. To obtain this loading space, the cushion of the rear bench type seat pivots about its forward edge and is stowed against the back of the

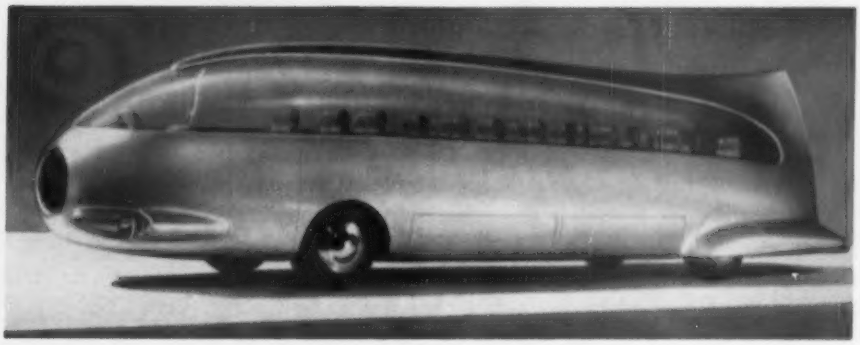
In the Eisenacher, the fins in the upper 3¾ in of the radiator block are closely spaced and this portion forms the exchanger for the interior heating system

The pull-out type door handles of the Eisenacher fit almost flush with the panels, a small rubber stop being fitted between their rear ends and the panels

On the B.M.W. 507, the plastics hard top can be fitted relatively easily for use during the winter months, and the styling of the vehicle gives a free flow of air over all four of the brake drums

The traditional radiator grille has been retained in the modern styling of the B.M.W. 503, and the length of the body is accentuated by the forward extension of the wings to house the headlamps

Left: The interior of the Peugeot 403, showing the dash facia and one of the front seats folded down to form a bed. Right: The lower end of each of the squab side frames is slotted to receive a peg passed through the socket, into which it fits when the squab is in the normal position, and the frame that carries the cushion is mounted on two double-acting adjuster channels



The Viberti Golden Dolphin coach is of glass-reinforced plastics construction. It has independent suspension on all four wheels and is designed for very high-speed operation

front seat, while its squab is folded flat on the floor to form a level platform.

The Goliath Juwel is powered by a 900 cm³, two-cylinder two-stroke engine. This unit has a stroke of 80 mm and a bore of 84 mm. Its compression ratio is 7·7:1, and the power output is 40 b.h.p. at 4,000 r.p.m. This high power output and a good fuel economy are obtained by the employment of the Bosch fuel injection system. The maximum speed of the vehicle is said to be about 75 m.p.h. and the consumption claimed is 42 m.p.g. The engine is installed laterally in front of the wheels and the radiator is in the conventional position, immediately behind the grille. This engine arrangement enables the bonnet to be kept to a reasonably short length; in addition, the front overhang is not excessive. A small water pump is bolted to the end of the dynamo. Special attention has been devoted to silencing, because of the inherent noisiness of two-stroke engines. An air intake filter is fitted on the dash and is connected by a duct to a silencer installed laterally behind the radiator. Thence another duct is taken to the engine air intake. Also on the dash is a large tank, which is divided into two compartments, one for oil and the other for petrol. A plastics lid is fitted over the battery.

All the models shown were of the two-door design. They have wrap-round rear lights and curved windscreens. Both the bonnet and boot release control knobs are inside the car. The boot release is under the armrest on the rear quarter panel and the bonnet release is, of course, under the dash. A bench type front seat is employed, but it has a divided squab. An unconventional fastener is used for the triangular ventilating panel in front of the drop glass on each door. It is an over-centre toggle lever, instead of the more usual pivoted lever.

An all-steel body is employed and it is welded to a tubular frame. Its overall dimensions are: length 13 ft 4 in, width 5 ft 4 in and height 4 ft 10 in. The wheelbase is 7 ft 7 in and the track is 4 ft 3 in at the front and 4 ft 1 in at the rear. A four-speed, synchromesh gearbox is employed The ratios are: 4:1, 2·33:1, 1·4:1, 0·875:1, and the reverse gear ratio is 3·83:1. An axle ratio of 4·73:1 has been adopted.

Peugeot

The mechanical features of the Peugeot 403 are much the same as those of the 203 but the body, of course, is completely different. A cylinder bore diameter of 80 mm has been adopted instead of the 75 mm of the 203, and the stroke, which is the same for both, is 73 mm. This gives a swept volume of 1,468 cm³. The power output is 58 b.h.p. at 4,500 r.p.m. Hemispherical combustion chambers are incorporated and the overhead valves are actuated by rockers, push rods and a single camshaft, the layout being that patented by Peugeot in 1948.

A four-speed, all synchromesh gearbox, with an overdrive top speed, is employed. The overall ratios are 4·38:1, 5·75:1, 8·85:1 and 19·78:1. A wheelbase of 8 ft 8½ in has been adopted and the track is 4 ft 4¾ in at the front and 4 ft 2 in at the rear. The overall dimensions of the vehicle are: length 14 ft 7½ in, width 5 ft 5½ in, and height 4 ft 11½ in.

Under the bonnet there are several features that are unusual and, therefore, of interest. The drain plug for the cooling system is actuated by a lever in a gate bolted to the rear end of the cylinder block. This lever is pivoted at a point level with the base of the crankcase casting, to which it is attached. Above the hinge, it passes through an eye on the end of a pull-out type cock in the base of the cylinder block water jacket. Lateral movement of the lever towards the engine pushes the cock into the block and seals it against the rubber ring. Movement away from the block pulls the cock out so that it is free to run. This is rather an elaborate arrangement, but it is a useful feature in very cold countries, where ease of access to, and simplicity of operation of, the drain cock is important. The heater element, together with its fan, is mounted on the front end of the vehicle structure and has a conventional drain cock. A fairly small radiator is employed. Its core is 14 in × 13 in × 1½ in thick. A plastics cap is screwed on to the filler neck. Pressurization is regulated by means of a small valve in a brass housing mounted on the end of the overflow pipe, just inside the filler neck.

A glass reservoir is fitted on top of the brake master cylinder so that the oil level can be checked readily. This reservoir is simply a glass cylinder with identical openings at each end. The filler cap is screwed on to the upper end; at the lower end, a similar cap, with a large diameter hole in its centre, forms a ring nut by means of which the reservoir is clamped to a circular flange on top of the master cylinder casting. Glass is not suitable for reservoirs for water because they are liable to be broken if the water freezes. When windscreen washers are fitted to Peugeot cars, a metal reservoir is employed.

Inside the vehicle, the front seat squabs can be folded backwards to form a bed. Each end of the frame that forms the vertical side members of the squab projects downwards into a socket on each side of the frame that carries the cushion. A slot is formed in the lower end of each side of the squab frame and a pin is passed through the side walls of the socket and the slot. Thus, to fold the squab back, it is necessary to lift it so that the ends of its frame slide out of the socket, and then to fold it down by pivoting it about the pin, which, when the squab is in this position, is at the lower end of the slot. The seat cushion is removed and replaced back-to-front, otherwise its slope would be in the wrong direction for use as a bed.

Each seat is carried on two double rails. The lower rail in each double unit is to accommodate the forward movement of the seat necessary to bring the top of the squab in line with the front edge of the rear seat cushion, when the seat is used as a bed. In normal use, the seat is locked in the rearward position on this rail by a hairpin clip passed laterally through one of the double rail units. The upper

rail in each assembly is for normal adjustment to alter the driving position.

Miscellaneous features

Among the American exhibits was the Chevrolet Corvette. This vehicle is now being exported to Switzerland, whereas previously it was for sale only in America. Its basic price in Switzerland is 25,500 Fr. and with extras it costs 29,500 Fr. One of the extras is a hard top, which is secured to the head rail by two toggle clips and to the tonneau cover by three set screws. Thus, it can be readily removed in the summer season and the folding hood, which is stowed under the tonneau cover, used when necessary. This hood is power-operated.

Evidently, Chevrolet have thoroughly mastered the technique of manufacturing body panels in plastics, for the finish of the vehicle shown was excellent and in style it was in no way inferior to conventional metal bodied cars. The advantages of plastics materials are, of course, well known. They include good resistance to damage and complete resistance to corrosion. Light weight and ease of repair are also attractive features of this material.

Viberti of Turin created a sensation by showing for the first time a fully streamlined coach, the Golden Dolphin, designed for a cruising speed of 125 m.p.h. This speed certainly sounds fantastic, but it is of interest to note that these manufacturers are thinking in terms of improved trunk roads—in a country that already has the autostrada. There can be but little doubt that the trend, throughout the world, will be towards higher operating speeds for long distance coaches. It is estimated that the speed of 125 m.p.h. will be obtainable when a gas turbine is installed. However, in view of the fact that considerable development work remains to be done on this type of power unit, the coach will be introduced in the first place with a conventional piston engine and, of course, will not be capable of such high speeds.

Two different seating arrangements have been planned, one for the accommodation of 18 passengers in separate swivelling and reclining seats and the other for carrying 32 passengers under less luxurious conditions. The vehicle is said to be built entirely in plastics, without any metal framing. Experimental work is being done with polarized glazing material, but the vehicle shown had a one-piece transparent plastics panel forming the whole of the structure above the waist rail. In shape, the body resembles an aeroplane fuselage and the driver sits at the centre of the extreme front end. There are two doors, one at each side; they are unconventional in that they are below the waist rail, which is relatively high. Access through these doors is easy. This is because, as the doors are opened, the platform immediately inside them retracts to give access to the steps up into the vehicle. With this arrangement, there is no danger of passengers bumping their heads on the waist rail as they mount the steps. The vehicle has complete air conditioning and there is space at the rear end for a buffet, refrigerator and other equipment.

Independent suspension of the double transverse wishbone type is employed both at the front and at the rear. Torsion bar springs are used in conjunction with anti-roll bars. The engine is mounted under the floor between the two suspension units and it drives the rear wheels. With this arrangement, of course, single wheels are employed at each side. This has been made possible by the employment of plastics to reduce weight to a minimum. The manufacturers emphasize that the vehicle is not displayed as a dream-car of the future but that they do intend to go into production with it. Nevertheless, it would appear that they inevitably will have to face a formidable development programme.

Nylon in Industry

THE tremendous potentialities of nylon for belting have been becoming apparent in British industry for some time past. Several types of nylon belting and drives are already achieving a high degree of success because their strength and durability makes them a long term economy and because, in some instances, they are responsible for significant increases in production.

Nylon has four basic properties which suit it admirably for the tasks of driving, lifting and carrying: (1) It has greater powers of energy absorption than any other textile fibre and is well able to withstand the strain of unequal loads; (2) it has very high fatigue resistance and can withstand severe flexing for long periods ensuring trouble-free running and sometimes enabling speeds to be increased; (3) it has high tensile strength which enables it to undertake a greater volume of work than conventional textiles; (4) it has very great resistance to abrasion and consequently an extremely long serviceable life.

There are several other properties which are also important. It is very light in weight; it retains its high tensile strength in folded constructions; it has good adhesion to rubber; it retains a high proportion of its strength when it is wet; it is immune to bacteria attack and therefore cannot rot; when necessary extensibility can be controlled to within fine limits by fabric construction or the use of heat-stretched yarn.

Nearly all the drop stamp belting now used in Britain's drop forges is now made from nylon. On average a nylon belt lasts about three times as long as a hair belt although the initial cost is only very slightly greater. A nylon belt is frequently smaller than the hair belt which it replaces. In a big drop forge at Smethwick one 30-cwt hammer used to be fitted with a nine-inch, 14 mm, double hair belt which used to last between eight and ten months. This was replaced by a single eight-inch, 10 mm, nylon belt which was still in use after two-and-a-half years.

The firm's experience with head straps is even more outstanding. Hair head straps used to last three or four days; nylon head straps are now lasting three or four months. When it is reckoned that 20 or 30 minutes are lost each time the head straps are changed, the saving runs into hundreds of man-hours during the course of a year.

Factories are already making use of certain types of transmission belting made wholly or partly from nylon. One type of belt consists of nylon bonded to chrome leather. When this was tested on a specially constructed "murder machine" it lasted for between 30 and 50 hours whereas conventional belting broke down after 11 minutes at the most. These test results are not so unreal as they may seem. There is at least one instance on record of a belt under actual working conditions outlasting a set of V-belts by 150 times. Another belt of the same type doubled the output of a 1,000 r.p.m. Heald Borer and has a substantially longer life than the set of V-belts it replaced. The number of boring heads has been increased from three to five; slippage which used to smash tools has been eliminated; depth of cut and cutting speed have both been increased by 50 per cent.

The use of nylon fabric for the jackets of V-belts is now widespread. Nylon's very high resistance to abrasion helps to ensure a long life by preventing much of the external damage which conventional V-belts suffer.

Some manufacturers are also using nylon for the load-bearing cords in the body of the belts.

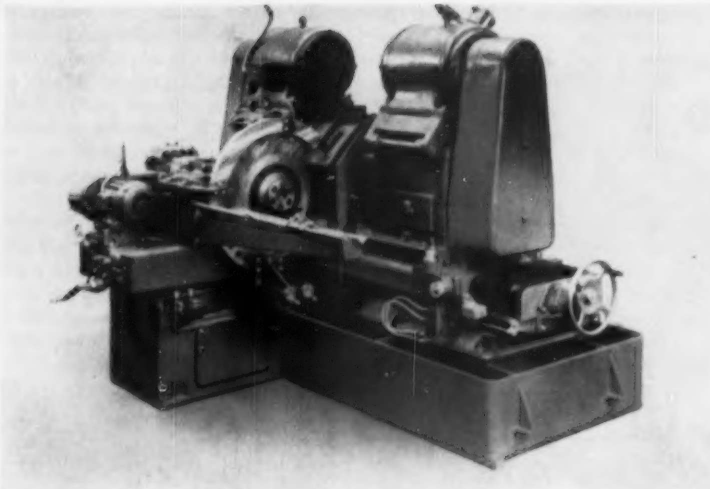


Fig. 1. Latest type Scrivener duplex grinder

Fig. 2. Work carrier for rods and caps

Duplex Surface Grinding

Recent Developments by Arthur Scrivener Ltd.

ALTHOUGH it is for work in developing centreless grinding machines that Arthur Scrivener Ltd., Tyburn Road, Birmingham, is best known, the organisation has also carried out work on other types, such as duplex surface grinders. The latest type of Scrivener duplex surface grinder is shown in Fig. 1. On this machine coarse positioning of each wheel head is ensured by means of an hydraulic system which eliminates all backlash. Each of the two hydraulic cylinders is under the control of a simple valve.

For final sizing, or for taking up wheel wear during production runs, the machine illustrated is equipped with a push-button micro-sizer. This is an hydraulically operated mechanism under remote control. Pressure on the operating button advances the wheelhead by a predetermined amount, which may be any one of five steps from 0·0001 in to 0·0005 in according to the setting that has been chosen. Another important feature is a dial indicator for each wheelhead. This gives a visual indication in increments of 0·0001 in of the exact advance or setting of the head in relation to a previously fixed zero position. This greatly facilitates setting up.

The duplex type of surface grinder lends itself to a great variety of automatic and semi-automatic feed arrangements. For example, the machine illustrated is equipped with a work carrier for valve seat inserts. The workpieces are gravity fed along a feeding chute, and are picked off one by one by the rotation of the circular work carrier, which has a series of suitable size holes along the outer edge. Larger pieces can be fed between the grinding wheels by means of a horizontal endless-chain type of conveyor, while larger circular pieces can be fed by means of pressure rollers along horiziontal guide rails.

In a recent interesting development, a machine of the type illustrated in Fig. 1 has been adapted for grinding both

Fig. 3. Detail of the rod work fixture

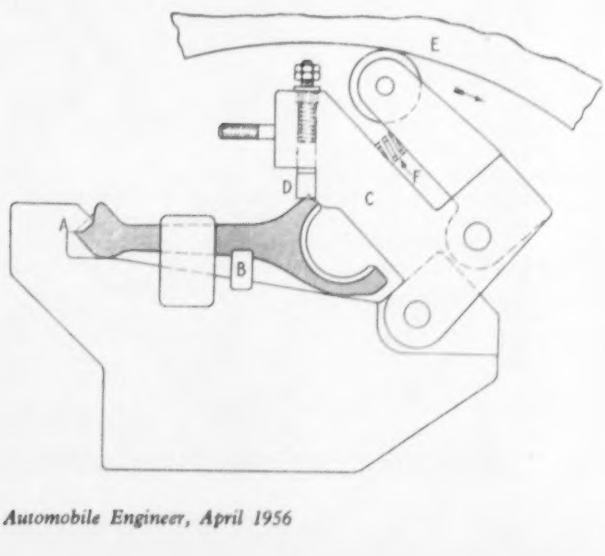
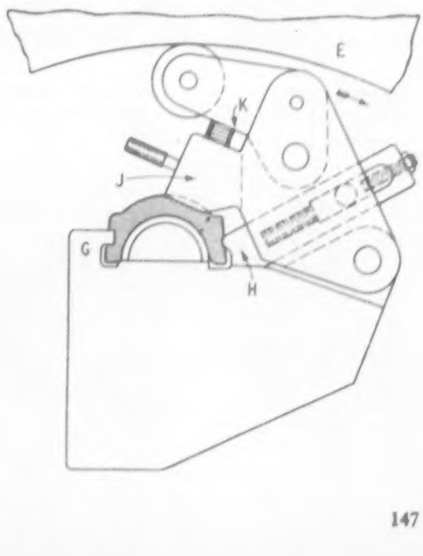


Fig. 4. Detail of the cap work fixture



sides of an engine connecting rod and its cap at one operation. The rotary work carrier for this application is shown in Fig. 2. It has a number of rod fixtures and a number of cap fixtures. An important feature of these fixtures is the provision for locating the work accurately in relation to the central web and the bosses. This is essential since the ground bosses act as location faces at subsequent and important operations.

Fig. 3 shows the method of locating and clamping the connecting rod forging. The forging is inserted against the location vees, A and B; the clamping arm C is then swung into position by hand and the upper vee D registers the work vertically. As the work holder slowly revolves, the roller arm is brought under the cam ring E, and pressure is applied to the clamping arm by the spring F. This spring pressure is necessary in order to accommodate variations in forging dimensions. When the fixture and workpiece emerge from between the grinding wheels and the surrounding cam ring, the clamping ring opens and allows the ground piece to fall into a convenient chute. The cap fixture is shown in Fig. 4. Initial location is effected by the fixed vee G, and then by the sliding vee H, when the clamping arm J is swung over. Final clamping pressure is applied by the spring K as the roller is brought, by rotation of the work carrier, under the cam ring E.

By means of a variable-speed unit, the speed of the work carrier can be varied between 1 and 3 r.p.m., to suit the amount of stock to be removed. In many cases the stock removal is heavy, amounting to as much as 0·030 in per side. Assuming, however, a reasonable stock removal of 0·015/0·020 in per side, the production rate is three rods and three caps per minute to tolerances in the order $\pm 0{\cdot}002$ in.

Gear Hobbing

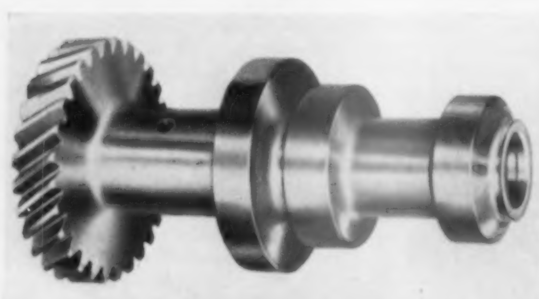
W. E. Sykes Ltd. Introduce a New High Production Machine

A NEW high production hobbing machine has been introduced by W. E. Sykes Ltd., Staines, Middlesex, England. This machine, the SPH.8 has been specially designed for high rates of stock removal and, in consequence, the entire unit has been built to exceptional power and strength specifications. The robust construction is not limited to such parts as the heavily ribbed box section castings, but extends to all sections of the working mechanism.

Heavy-duty anti-friction bearings are used throughout, gearing is of ample proportions to resist the stresses imposed by modern cutting techniques, and involute splines displace keys and keyways in the large diameter, tubular section shafts. Rigidity during the cutting process is assured by the use of unusually large diameter hob spindles.

That the designation "high production" is no empty boast can be seen from the production rate for the shaft illustrated. The gear shown can be regularly cut in manganese-chrome oil hardening steel, EN.18C, in a floor-to-floor time of only 60 seconds. The pitch circle diameter is 3·188 in, the face width [illegible] in, and the gear has 29 teeth of 11 N.D.P., 30·42 deg helix angle and 20 deg pressure angle. The degree of accuracy obtained in this time is well within the requirements for finishing by the shaving process.

This manganese-chrome gear, pitch diameter 3·188 in and face width $\frac{3}{16}$ in, is cut in 60 seconds floor-to-floor time on the new SPH.8 hobbing machine



The maximum capacity of this machine is 13 in diameter by $4\frac{3}{4}$ in face width, with pitches up to and including 4 D.P. The SPH.8 will generate with accuracy spur gears, left and right-hand helical gears of any helix angle up to 40 deg, splines and serrations. Large diameter multi-start hobs enable the maximum number of cutting edges to be provided, and excellent results can be obtained with less costly machine-relieved hobs.

Automatic hob-shift mechanism is incorporated to ensure that wear takes place evenly across the entire width of the hob. Thus, the longest possible productive hob life is obtained. The hob-shift can be pre-set by means of a dial, graduated so that one division equals 0·0026 in axial hob movement. It can be regulated to occur automatically on the completion of each component, or by depressing a button after a pre-determined number of parts has been cut. The hob-shift is simply adjusted by moving dogs along a draw bar with a maximum travel of 4 in.

A signal lamp indicates that the maximum travel has been obtained when, on pressing the "return" button, the hob returns to its initial position. Alternatively, the movements can be reversed by a changeover switch. Full electrical interlocks are provided so that hob-shift cannot take place until the main motor has been stopped and the hob head is completely disengaged.

Hydraulic feeds are incorporated in the driving mechanism, the lead being controlled by a guide unit, which eliminates inaccuracies normally associated with differential change gears. This guide unit is similar to that employed on Sykes gear generating machines, and any desired lead from 7 in may be obtained. The unit is housed in a yoke designed to permit ready access for changing the guide.

The SPH.8 has a particularly simple operating cycle. The work is mounted on a suitable fixture and accommodated in the headstock spindle. Following this, the entire cycle is automatic. The tailstock moves in and engages the work arbor, the hob and the component revolve, and the coolant flow is started. The tooth depth having been set beforehand, the hob head advances to plunge feed the hob into the work. When full tooth depth has been achieved, the component traverses across the hob, the hob head and work spindle return to their original positions and the coolant flow ceases.

Philips mains-operated Roughness Tester, complete with pickup and box of standards

The Philips Roughness Tester

A Portable Instrument for Measuring Surface Finish Under Workshop Conditions

FEW metal surfaces can be described accurately as even approximating to perfect smoothness. Every method of machining leaves its characteristic pattern of microscopic crests and valleys. These undulations affect not only the fatigue strength of stress-bearing elements, and the dimensional fit and performance of sliding and rolling parts such as shafts, pistons and bearings, but also the quality of plated items, bumpers and grilles, for instance. Although it has not been proved conclusively that the surface finish of the base metal affects the life of chromium-plated parts, it is obvious that choice of an appropriate grit size for scurfing will affect the visual quality of the final polish. For such reasons it is becoming more common to specify a surface finish in absolute terms of micro-inches C.L.A.—the centre line average of the crests and valleys of the surface—rather than in qualitative terms of surface texture such as turned, reamed, honed, lapped or mirror finishes.

The Roughness Tester being used by a lathe operator on work in progress

This practice necessitates an accurate means of ascertaining that finish is within prescribed limits. Scratching the surface with a finger-nail is quite inadequate, as also is a visual examination. On the other hand, the use of precision laboratory equipment, such as the "Talysurf," is rarely economic on the production line. In any case, it would require the services of a skilled operator. The Roughness Tester produced by Philips Electrical Limited, Century House, Shaftesbury Avenue, London, W.C.2, offers a solution in that it is sufficiently accurate for all normal production purposes but, nevertheless, can be used in the shop by semi-skilled operators after only brief instruction.

The unit is mains-operated, weighs only 13 lb and measures 11 in × 11 in × 7 in. It is, therefore, easily portable and can be set up alongside a machine, on an inspection bench, or anywhere a power supply of 110-245V, 40-100 c/s is available. The equipment comprises a piezo-electric pickup with a sapphire stylus, a set of reference surfaces, and a selective amplifier giving direct reading on four different scales:— 250–50, 60–10, 16–3, 4–1 micro-inches respectively. The comparison standards are machined to a finish approximating to the middle value in each of the above four ranges and each standard is then individually calibrated by "Talysurf" measurement.

Operation of the Roughness Tester is simple. The appropriate standard is selected by visual comparison with the workpiece and the instrument set to the corresponding measurement range. The pickup, lightly held between thumb and forefinger, is traversed to and fro across the standard surface. This produces a deflection on the meter and the instrument's gain control can then be adjusted until a steady reading is obtained at a point on the scale corresponding to the "Talysurf" value of the standard. The

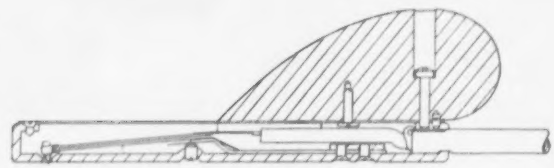
Reference standards are boxed for protection. This view shows the manner of holding the pickup when taking a reading

instrument is then set for use on that range and thereafter the operator can check on any part of a component in roughly 30 seconds.

The pickup weighs only 1 oz and is less than the size of a cigarette; the actual dimensions are 2 in × $\frac{5}{16}$ in × $\frac{1}{4}$ in. Readings can, therefore, be taken without removing a workpiece from the machine. They can also be obtained inside bores down to $\frac{3}{8}$in diameter and in other components difficult of access. The pickup has a wing-shaped grip to give the operator a better hold when using it with oily hands. Accuracy of reading, it is claimed, is to a maximum error of $\pm$10 per cent and this should be reduced with practice by the operator.

Any surface can be used as a comparison standard. A component known to be of acceptable finish can be taken from production and the appropriate range of the Roughness Tester adjusted accordingly. Samples or batches of workpieces can then be checked to ascertain whether they conform to, or to what extent they differ from, the accepted values used as a reference. Non-metallic surfaces such as ceramics or plastics can also be tested in this way.

When working to fine tolerances, as on piston rings, crankshaft journals, and similar items, where it is essential that a specific micro-finish be produced but where a finer finish would involve a wasteful expenditure of production time, the Roughness Tester can be used by a machine operator for continuous checks. To achieve maximum accuracy of reading, it is recommended that the pickup be traversed a distance of $\frac{3}{8}$-$\frac{3}{4}$ in across the work surface at a rate of two or three strokes per second. If this procedure is followed the effects of involuntary hand movement are then nullified and a steady reading is obtained.



Section of the Roughness Tester pick-up

The Barrymount Isolator

A New Method of Mounting and Levelling Machine Tools

NUMEROUS difficulties attendant on the installation, removal, or re-location of machine tools are neatly circumvented by the use of these standardized mounting units. They prevent the transmission of vibration, whether from machine to floor or *vice versa*, and consequently the machine loses any propensity to walk the floor and need not be bolted down. Each unit incorporates a simple levelling device; a single bolt that is secured in the adjusted position by a lock nut.

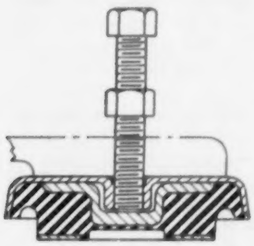
Barrymounts, as they are designated, were originally developed in the U.S.A., by Barry Controls Inc., Watertown, Mass., and are now manufactured in Britain by Cementation (Muffelite) Ltd., 39 Victoria Street, London, S.W.1. They comprise a flanged annulus of Neoprene oil-resistant synthetic rubber to which is bonded a recessed support plate, a base plate, and also, over the periphery of the flange, a dished cover plate having a central boss which is internally threaded to receive the levelling bolt. As the bolt is screwed into the cover plate its end abuts the recess in the support plate and continued movement displaces the cover plate upwards to lift and level the machine to which it is fitted.

The mounts are produced in three sizes ranging from $4\frac{3}{4}$ in diameter to $9\frac{1}{2}$ in diameter and each is available with four different grades of Neoprene to give varied load characteristics. Over the range of standard units the load rating rises from 70-90 lb to 1,850-2,500 lb. In all cases these standard ratings result in the vertical natural frequency of the mount being approximately 20 c/s. This frequency has been found most suitable for the majority of normal applications, but in specific cases optimum performance may be obtained with different values. The free height of the mounts ranges from $1\frac{1}{2}$ in to $2\frac{5}{8}$ in and the permissible additional height for the purpose of levelling is $\frac{1}{2}$ in in all sizes. By the use of screwed adaptors some variation of bolt size is possible. The medium size mount may have

Each Barrymount incorporates a screwed levelling adjustment

bolts of $\frac{3}{8}$ in, $\frac{1}{2}$ in and $\frac{3}{4}$ in diameter, while $\frac{1}{2}$ in, $\frac{5}{8}$ in, $\frac{3}{4}$ in and 1 in diameter bolts can be accommodated in the largest size. Two different versions of the smallest size are fitted with $\frac{3}{8}$ in diameter and $\frac{1}{2}$ in diameter bolts respectively.

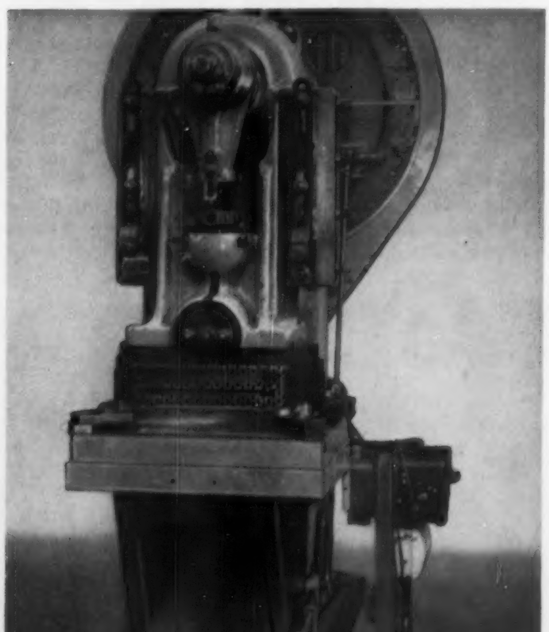
Manifold advantages are claimed for this method of machine mounting. Installation of a machine requires no floor preparation. There are no holes to be cut out, no rag-bolts or anchor plates to be made, and there is complete freedom to locate exactly where desired as no consideration need be given to the run of conduits, pipes, reinforcement

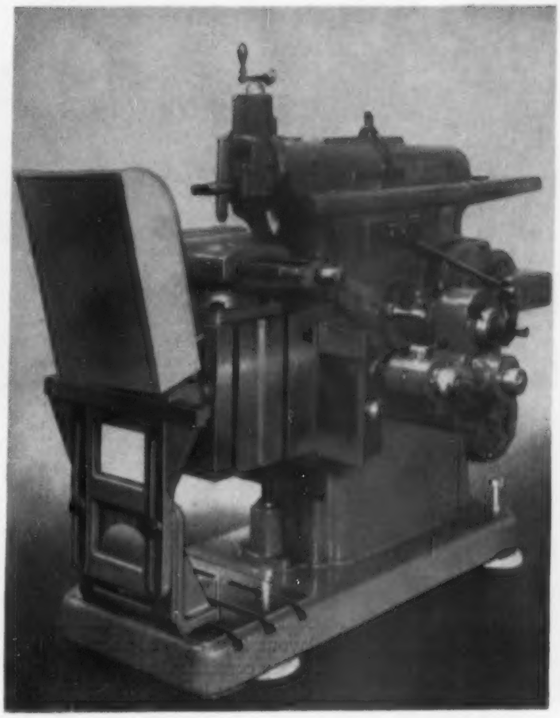


Sections showing the mount fitted below a machine foot. Left: as initially installed. Right: after levelling and locking

rods or girders. After the machine has been moved into position the foot is lifted and a mount placed underneath. The levelling bolt, complete with lock nut, is passed through the holding-down hole and screwed into the mount until it bottoms on the support plate. When each foot has been supported in this manner the bolts are adjusted to level the machine precisely and are then secured by the lock nuts. The need for packing up to level the machine, and grouting in with cement is eliminated. If a machine fitted with Barrymounts needs to be moved from its position and re-located, as when arranging or modifying a production line, it requires merely to be lifted, transported, set down in the new position and levelled. The complete operation can be performed in a period of minutes instead of hours, the machine can immediately be put into operation and the vacated site needs no repair and is immediately available for other equipment.

Raskin No. R6 100-ton press on Barrymounts. (Messrs. G. A. Harvey & Co. Ltd., London)





Invicta 4M 18 in shaping machine anchored on four Barrymounts. (Messrs. S. Smith & Sons Ltd., Cricklewood)

The ability of the mounts to absorb vibration makes it possible to arrange machines in a production line to the best advantage. A sensitive, precision machine can be located adjacent to, for instance, a punch press without ill-effect. For the same reason better utilization of available space may be possible as machines can be set up nearer to administrative or drawing offices or to laboratories than would otherwise be practical. In some instances the fitting of these mounts, by cushioning machine vibration, enables production to be speeded by the use of heavier cuts, higher speeds, or harder carbide tools.

All types of machine tools can be satisfactorily installed with these mountings. The obvious cases are such machines as presses or shears in which the reaction to impact during operation is vertical. A supplementary advantage of the resilient mounting in such applications is freedom from the frame stresses encountered in rigidly bolted-down installations. Other machines in which there is a substantial horizontal reaction can, however, be successfully mounted without any tendency to walk. The shaping machine illustrated is a case in point. Heavy machines can be anchored by more than the usual four mounts, arranged either individually or grouped at convenient locations.

In the U.S.A. a Bliss 400-ton press, having a deadweight of about 12 tons, has been set up and operated in a period of less than 30 min. A Grand Rapids precision surface grinder, with a 9,000 lb table reciprocating at 150 ft/min, was installed on twelve Barrymounts.

The de luxe model of the Renault Dauphine has imitation wire wheels mounted over the standard wheels, which are of the type used on the earlier 4CV models

THE RENAULT DAUPHINE

First Impressions of the Latest of the Rear Engined Vehicles

SINCE the Regie Nationale des Usines Renault have adopted the rear engine layout for their latest model, the Dauphine, it is evident that they consider that the advantages of this arrangement more than offset its disadvantages. Nor is this assessment of the relative merits of the front and rear engine layouts based solely on the theoretical considerations, for this manufacturer has had the benefit of many years experience with the highly successful 4CV model. The disadvantages, of course, are an adverse front : rear weight distribution, which tends to cause oversteer, and because the width of the compartment under the bonnet is restricted by the size of the wheel arches necessary to accommodate the front wheels on full lock, there generally is little space for luggage. So far as the luggage space is concerned, the Renault Dauphine is a great improvement on the earlier model. In fact, the space available is as large as that in some cars of more conventional layout; however, it is still not as good in this respect as the best of the conventional vehicles of the same size. The front : rear weight distribution in the unladen condition is almost exactly the same as that of the 4CV. The most important advantage of the rear engine layout is that for a given size of car, it enables the greatest amount of space to be made available for the passengers. This is borne out by the fact that in the Renault Dauphine, there is ample accommodation for four people in comfort.

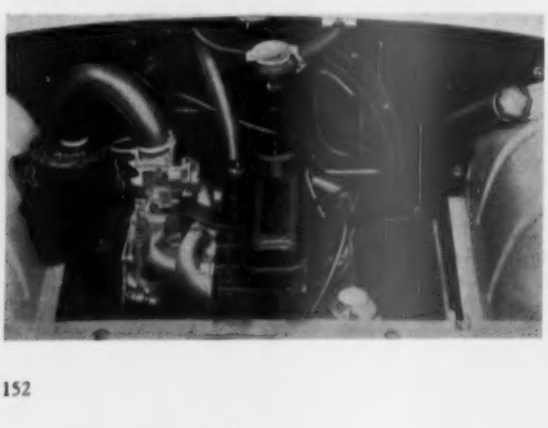
Many of the components are common to the Dauphine and 4CV models. Moreover, some, which have been designed expressly for the Dauphine, will be introduced on the 4CV in the interests of rationalization. The track has been increased by 2 in at the front and 1 in at the rear; the wheelbase of the Dauphine is 6½ in longer than that of the 4CV model; and the overall length of the vehicle is 1 ft 1 in greater. This has not only considerably increased the space available for the passengers but also, since the extension has been made forward of the rear wheels, it must give improved weight distribution in the laden condition. This, together with the increase in wheelbase, has improved the handling characteristics of the vehicle.

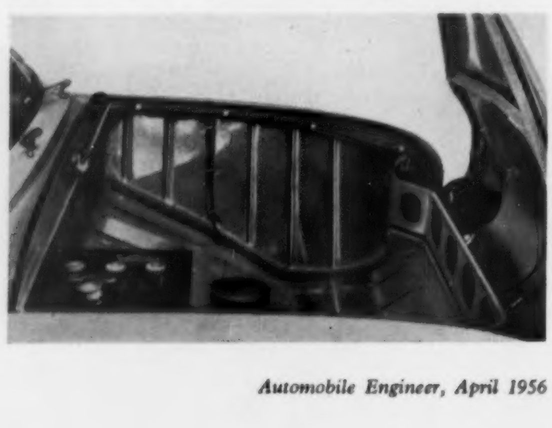
The dimensions are: wheelbase 7 ft 5 in; track 4 ft 1 in at the front and 4 ft at the rear; overall length 12 ft 11 in; width 5 ft; and height 4 ft 9 in. A ground clearance of 6 in has been adopted and the turning circle is 27 ft 5 in. The curb weight of the vehicle, with five gallons of petrol, is 1,324 lb, and the front : rear weight distribution is 39·3 : 60·7.

Inside, the principal dimensions are as follows. From the top of the clutch pedal to the base of the rear seat squab, the distance is 57¼ in, between the clutch pedal and the front edge of the driver's seat it is 17¼-20¼ in, according to the seat position, while from the front of the rear seat, the distance measured horizontally to the back of the front seat is 9¾-

Left: There have been few changes in the rear-engine installation. The starter handle and jack are stowed beside the right-hand wheel arch

Right: A large luggage compartment has been obtained and the electric wiring to the lamps is in a clean and readily accessible position





12¾ in. The space between the wheel arches at the level of the toeboard is 29 in and the total width, immediately behind the front wheel arches, is 50¾ in. At waist level, the distance between the centre pillars is 45½ in. The rear seat squab is 45 in wide at the waist, and at the cushion the width between the exterior panels, on which the trim is stuck, is 50 in.

The front door is 28 in wide at the waist and the rear one is 24 in wide at that level. At the floor level, the rear door is only 17 in wide, because of the intrusion of the rear wheel arches. The overall width of the centre pillar is 3¾ in. From the centre of the rear floor wells to the head lining, the distance is 46 in, and from the top of the tunnel to the head lining it is 43¼ in.

All four doors are hinged at their forward edges. The seals on the doors are of soft rubber and a conventional draught excluder is fitted round the flanges of the door openings. All the handles on the inner faces of the doors are plastics covered except the door pull, which is a painted brass handle, pivoted at each end. There are no stops to hold the door in the open position.

The front doors have vertically sliding glasses and triangular ventilation panels. Each rear door has a fixed rectangular glass panel in front and a horizontally sliding glass panel behind it. A rubber strip is fixed to the glazing rail on the rear of the fixed glass and its edge trails over the sliding glass to form the seal between the two. There are no cappings round the edges of the side lights except over the channel that carries the lower edge of the sliding glass. This capping is screwed to the waist rail and can therefore be removed for renewal of the sliding glass. The full width wrap-round rear light has a relatively small radius of curvature, and is not, as is more usual, swept round sharply at each end. The windscreen, however, is of conventional form, with a moderate radius of curvature.

On the facia, there is a single instrument containing indicators for the speedometer, without a trip indicator, and petrol and water temperature gauges. Also under the same glass are the dynamo charge and oil pressure warning lamps. A large hood is fitted over the instrument to prevent reflections at night. To the left of this is a very small glove box, 5¼ in wide × 3 in deep, and a larger box is incorporated on the extreme right-hand side of the facia. The radio is mounted in the centre, and above it is an ashtray.

The demister slots are extremely close to the glazing rubber, which at first sight would appear to obstruct the air flow. However, this may be an illusion, since it is possible that it induces the flow to follow its profile and thus directs it on to the screen. A plastics or rubber-moulded strip is mounted on the lower edge of the facia. Presumably this is mainly to act as a finisher, but it would also help to protect the passengers from injury in the event of a crash.

The headlamp switch arrangement is similar to that on the 4CV. It comprises a lever on the end of a pedestal extending laterally from the steering column. This arrangement is convenient for Continental drivers, since it places the switch control within easy reach of their fingers when they are gripping the wheel. Headlamp signalling, of course, is

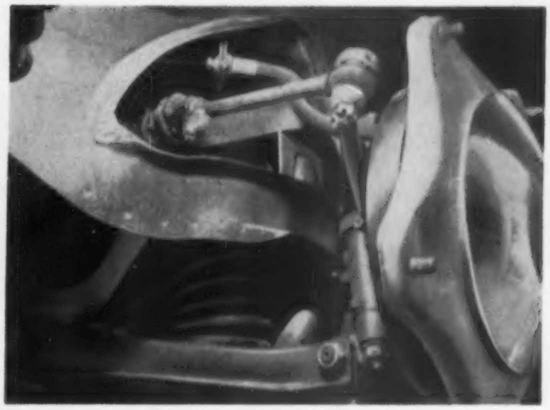
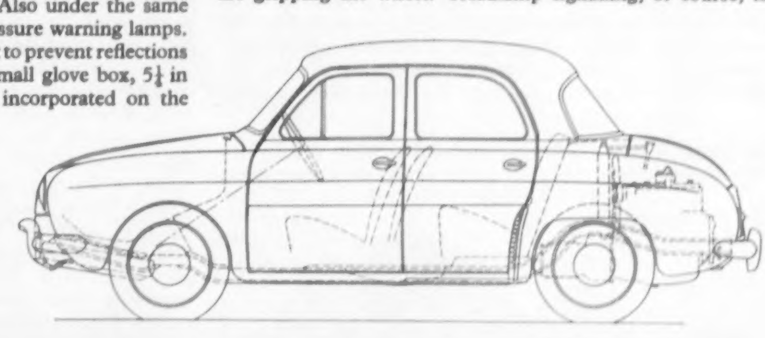


Illustration showing how the chassisless structure at the front end is cut away to clear the suspension components



***Right:** General arrangement of the Dauphine*

***Below:** The rear end appearance has been improved by incorporating the air outlet louvres in the skirt panel instead of the lid*

***Below, right:** Layout of the dash facia and controls of the Renault Dauphine*

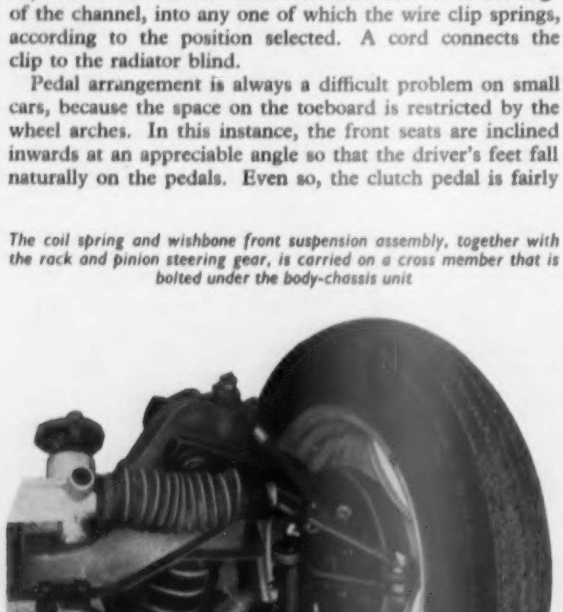
Left: The wing valance panels form an integral part of the front end structure of the Dauphine, and stowage for the spare wheel is under the floor of the luggage compartment

Right: The rear end structure is of sound design and light weight: it has ample strength and rigidity to carry the engine and rear suspension loads

universally used in the Continental towns, where cars are driven with side lights on, but the headlamps are switched on and off as the car passes each road junction. The control for the flashing direction indicators is a long lever extending laterally from the other side of the column. Also mounted on the column is the ignition switch, which operates the starter and can be used to lock the steering control. The control for the radiator blind is a wire clip that slides in a vertical channel mounted on the rear face of the wheel arch adjacent to the driver. There are four notches in the edge of the channel, into any one of which the wire clip springs, according to the position selected. A cord connects the clip to the radiator blind.

Pedal arrangement is always a difficult problem on small cars, because the space on the toeboard is restricted by the wheel arches. In this instance, the front seats are inclined inwards at an appreciable angle so that the driver's feet fall naturally on the pedals. Even so, the clutch pedal is fairly close to the steering column. A good feature of the arrangement is that there is plenty of room between the clutch pedal and the wheel arch to rest the left foot when the clutch is not being operated. Sturdy, tubular-framed bucket seats are fitted in front, and the bench type rear seat has a curved squab to bring its ends forward of the wheel arches. A two-piece, black rubber floor covering, slightly under $\frac{1}{8}$ in thick, is employed: one piece covers the front floor and the other the rear. Under the rubber, a $\frac{1}{4}$ in thick underfelt is laid.

The coil spring and wishbone front suspension assembly, together with the rack and pinion steering gear, is carried on a cross member that is bolted under the body-chassis unit



The front luggage compartment is indeed large for a rear-engined car. Its maximum dimensions are 35 in × 44 in × 16 in, although some of this space is occupied by the battery. This capacity has been obtained partly by adopting a relatively high scuttle and partly by extending the front end of the car forward, by comparison with the 4CV. Also, the spare wheel is mounted under the compartment instead of inside it, as in the 4CV. The cover for the spare wheel compartment is formed by the panel on which the number plate is mounted. Its release knob is inside the bonnet, the release for which is inside the car, so the spare wheel cannot readily be stolen when the car doors are locked.

A forward hinge arrangement has been adopted. This is a safety feature in that there is no danger of the lid lifting if the catch should come undone. However, it also has other advantages. The catch can be simpler, since a safety device is not needed; moreover, because it is on the scuttle, the run of the control is short. Since the lamps and the chromium plated components that decorate the front end of the car are close to the hinges, the bonnet opening can be made wide without fear of the lid being too heavy. Spring assistance is also unnecessary. Once the lid has been lifted beyond a certain point, that is, where its centre of gravity swings forward of the hinges, a tie instead of a strut is needed to hold it. This is an advantage, since a lighter stop can be used to hold the bonnet open. In this vehicle, a simple hairpin wire clip is employed. The two ends of the clip are attached to one side of the lid and it is passed over a peg on the wheel arch valance. Thus, as the lid is opened, the peg slides along the length of the clip until it is finally stopped by the rear end. The wire clip is so arranged that

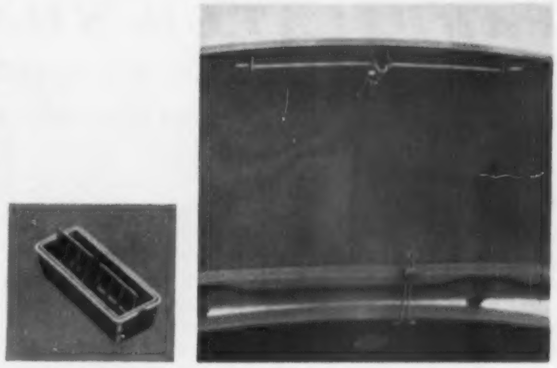
it tends to spring inwards against the peg so that it does not rattle. A similar stop is used to hold the boot lid open.

So far as the general layout of the mechanical components is concerned, this vehicle is not unlike the 4CV. It comprises a chassisless body structure; the power unit and rear suspension, mounted on a pressed steel cross member bolted to the structure; and the front suspension and steering assembly, also mounted on a box section cross member bolted to the main structure. The body sills form the frame side members and are swept inwards at the front and rear to clear the wheels. Two top hat section cross members are spot welded under the floor to form box sections. One is under the front seats and the other adjacent to the heelboard.

A four-cylinder in-line engine is employed. It is much the same as that of the 4CV model. The cylinder head is of aluminium alloy, and the cylinder block and crankcase casting is of iron. Wet cylinder liners are employed; they are now 58 mm instead of 54·5 mm bore, but the stroke remains the same at 80 mm. This gives a swept volume of 845 cm^3. The compression ratio is 7·25 : 1. A power output of 30 b.h.p., by the S.A.E. rating, is obtained at 4,250 r.p.m. The maximum torque is 48·4 lb-ft at 2,000 r.p.m., and the maximum b.m.e.p. is 142 lb/in^2.

A Solex 28BIT carburettor is fitted, and a thermostatically controlled hot spot is incorporated. The petrol tank, which holds 7 Imp. gallons, is mounted under the rear seat pan. A pressed steel shroud is welded round the exhaust downpipe, immediately below the manifold. This, no doubt, helps to shield the starter motor, generator and air cleaner from radiant heat.

Although the Ferlec clutch can be supplied as an optional extra, the standard transmission is a single dry plate clutch with a three-speed gearbox. Top and second speeds are synchronized. The ratios are: 3·7 : 1, 1·8 : 1, 1·07 : 1, and reverse is 3·7 : 1. A final drive ratio of 8 : 35 has been



Left: The ashtray in the centre of the dash can be removed for emptying and cleaning. Its pivoted lid, which is shown in the half-open position, has a grille on its underside

Right: A simple cranked wire catch is employed to secure the boot lid when it is closed, and the check stay that holds it in the open position is a simple hairpin type, spring clip

adopted. The swing axle suspension arrangement is the same as on the 4CV, and the wheel rims are attached by five studs to their discs, as before. A leading and trailing shoe brake arrangement has been adopted for both the front and rear wheels. Their drums are 9 in diameter.

A 15 in diameter, two-spoke steering wheel is employed. It requires 3½ turns to move it from lock to lock. As in the 4CV, a rack and pinion steering gear with centring springs is incorporated. The front suspension is of the coil spring and wishbone type. Telescopic shock absorbers are employed both at the front and rear.

MECHANICAL HANDLING

The First International Convention

AN International Convention—the first of its kind—will be held in conjunction with the Mechanical Handling Exhibition at Earls Court, London, 9th-19th, May, 1956. Experts from various countries will present papers discussing the latest developments in mechanical handling equipment and its application to their own industries. The full programme is:—

No. 1 Thursday, May 10th. Frank G. Woollard, Esq. M.I.Mech.E., Great Britain. "*Mechanical Handling—Prospects and Problems.*"

No. 2 Friday, May 11th. Lt.-Col. P. A. J. Hernu, Ceylon. "*Some Handling Problems in Ceylon.*"

No. 3 Monday, May 14th. Dr. F. Hegner, Switzerland. "*Modern Methods of Co-ordination of Interplant Handling.*" This will be followed by a film on palletization.

No. 4 Tuesday, May 15th. H. E. Stocker, Esq., U.S.A. "*Mechanical Handling in International Commerce—Conclusions from the Experience of 35 years.*"

No. 5 Wednesday, May 16th. Douglas A. Gillespie, Esq. (past National President American Material Handling Society Inc.). "*The Field for British Equipment in Canada and the United States of America.*"

No. 6 Thursday, May 17th. Details to be announced later.

No. 7 Friday, May 18th. Dipl. Ing. Gert Salzer, Germany. "*The Solution to Materials Handling Problems in Germany.*"

Each Convention Session starts at 3 p.m.

Tickets for the various sessions may be obtained free of charge on application to "*Mechanical Handling*" Exhibition, Dorset House, Stamford St., London, S.E.1.

The exhibition proper, while it will deal with every type of mechanical handling equipment, will include much that is of direct interest to the automobile and ancillary industries. For example, important developments in fork lift trucks will be on display. They will include machines small enough to operate in very narrow gangways; many attachments for special purpose lifting; slewing masts and side carriers for work in congested areas; and quickly replaceable masts and accessible moving parts to make maintenance easy.

Many developments in electro-hydraulic control equipment will also be exhibited. In this field, the development of duplex valve systems has allowed complex movements to be completely and accurately synchronized. Among the numerous devices applicable to operational control will be elapsed time indicators for determining the true operating hours of a plant; variable speed controllers for conveyors or machine tool feeds; counters; and check weighers and batchers for continuous weighing and packing operations. Improvements in the equipment itself include the production of moulded relays, the use of sintered contacts for resistance to corrosion, and increases in the speed and range of activating and relay devices.

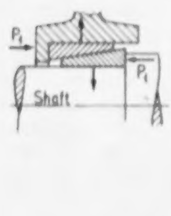
FABRICATED SHAFT COMPONENTS

Application of the Ring Spring to Lock Together the Components of Fabricated Crankshafts and Shaft Drives in General

COMPONENTS such as gears, pulley wheels, levers and even cams are sometimes keyed or splined on to their shafts. Similarly, torsion bars in most instances are located against rotation by splines, although because of the relatively high cost of this method of location, the Swiss Railways have employed less highly stressed, and therefore heavier, bars with their ends anchored in square holes. Another disadvantage of keyways or splines is that they invariably weaken the shaft. This can be countered by upsetting the end where the keyway or splines are cut, but this cannot always be done if bearings have to be fitted anywhere between the ends of the shaft. The seriousness of the reduction of shaft strength owing to the incorporation of keyways or splines is seldom fully appreciated, since the application of these methods has become largely a matter of habit.

Recently, investigations have been carried out by Leven, and published in an article entitled "Stresses in Keyways by Photoelastic Methods and Comparison with Numerical Solutions," *Proc. Soc. Exp. Stress Analysis*, Vol. 7, 1949, No. 2. These have shown that with shafts of diameter d, in each of which there is a keyway $d/4$ wide by $d/8$ deep, the maximum shear stress is 2·04, 2·23 and 2·66τ respectively when the radius r at the bottom of the keyway $=0{\cdot}1d$, $0{\cdot}05d$ and $0{\cdot}02d$, where τ is the nominal shear stress, determined from $\tau = 16M/\pi d^3$, imposed upon the shaft by a torque M. Thus, to avoid exceeding the permissible value of the shear stress it would be necessary to increase the shaft diameter 1·27, 1·31 and 1·39 times respectively. Apart from increasing both weight and cost of the shaft, this measure would in turn call for larger, heavier and more expensive bearings, housings and flanges, and would thus also affect the components linked to or fixed on the shaft. In addition, keyways and splines make sealing difficult, particularly in some applications where they are relatively easily attacked by corrosion.

Recently, it has been found that the ring spring is attractive as a device for locking components on shafts. The action and stressing of this device, invented by E. Kreissig, Dr. Ing. h.c., and manufactured by the Ringfeder G.m.b.H., of Krefeld-Uerdingen, was dealt with in some detail in the August 1955 issue of *Automobile Engineer*. Originally the ring spring was applied to railway buffers, and later it was used in gun recoil mechanisms and aircraft landing gear. An application of a ring spring as an alternative to keys or splines is shown in Fig. 1. Under the action of the axial force P_1, the outer ring expands while the inner one contracts thus securing the wheel hub to the shaft. The rings form a hermetical seal between the shaft and the hub; this is of particular advantage with shafts stressed in bending or exposed to corrosive influences.



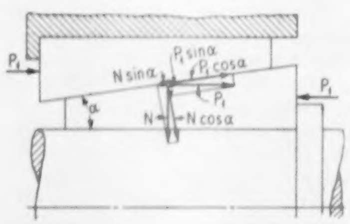


Fig. 1. Above left: The ring spring as a securing element

Fig. 2. Above right: Forces in a ring spring element

Fig. 3. Below: A multi-element ring spring assembly

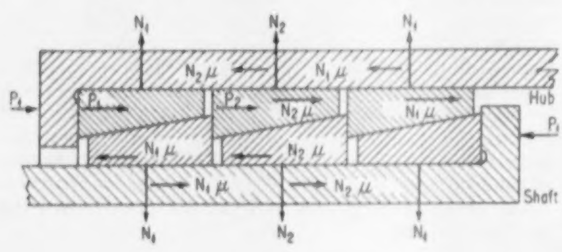


TABLE I.

μ	R			
	1 element	2 elements	3 elements	4 elements
0·1	$0{\cdot}25P_1$	$0{\cdot}4P_1$	$0{\cdot}5P_1$	$0{\cdot}57P_1$
0·12	$0{\cdot}286P_1$	$0{\cdot}445P_1$	$0{\cdot}55P_1$	$0{\cdot}616P_1$
0·15	$0{\cdot}333P_1$	$0{\cdot}5P_1$	$0{\cdot}6P_1$	$0{\cdot}676P_1$

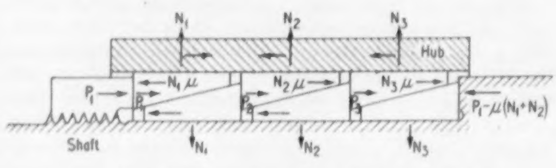
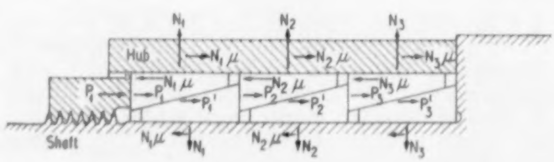


Fig. 4. Above: Three pairs of rings clamped on a shaft

Fig. 5. Below: Rings clamped on a shaft, but with the hub pulled against a collar



From the stress diagram, Fig. 2:

$$P_1 \cos\alpha = N \sin\alpha + \mu (N \cos\alpha + P_1 \sin\alpha)$$

or $P_1 (\cos\alpha - \mu\sin\alpha) = N(\sin\alpha + \mu\cos\alpha)$

where μ is the coefficient of friction. Rearranging:

$$N = P_1 \frac{\cos\alpha - \mu\sin\alpha}{\sin\alpha + \mu\cos\alpha}$$

$$= P_1 \frac{1 - \mu\tan\alpha}{\tan\alpha + \mu}$$

and simplifying by eliminating $\mu\tan\alpha$, the values of which are negligible:

$$N = \frac{P_1}{\tan\alpha + \mu}$$

or $P_1 = N(\tan\alpha + \mu)$

The force due to friction is:

$$R = N\mu = \frac{P_1\mu}{\tan\alpha + \mu}$$

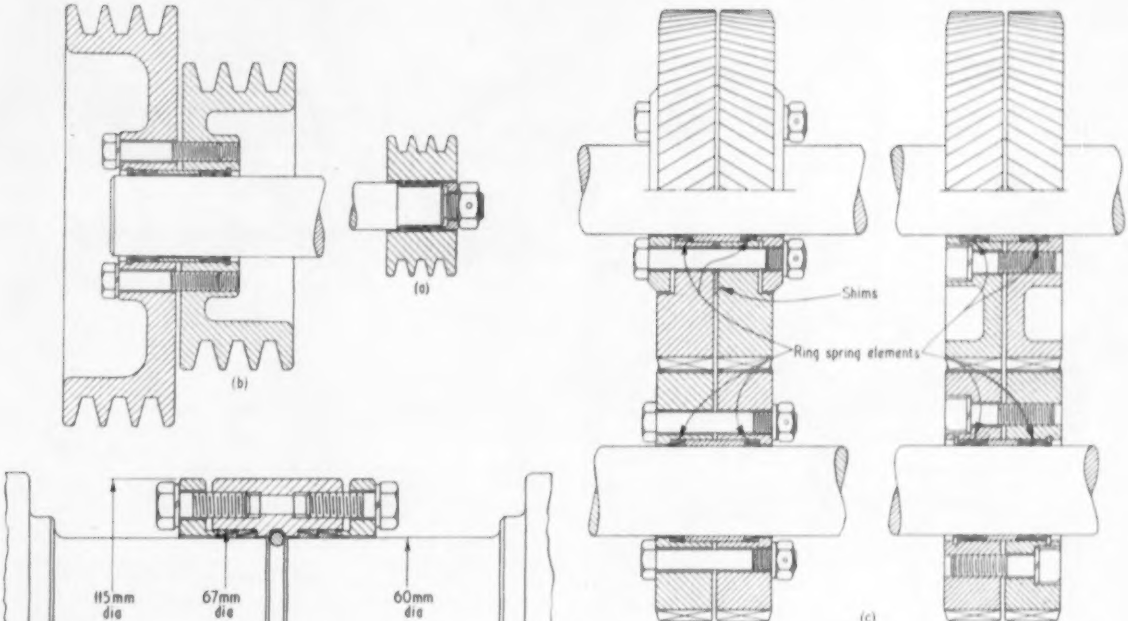


Fig. 6. **a** *Pulley at shaft end* **b** *Pulley on shaft* **c** *Double helical gear assembly* **d** *Ring spring coupling*

It is, of course, possible to assemble a number of ring elements in series, Fig. 3. If n ring elements are used, the sum of the radial pressure forces is:

$$\sum N = \frac{nP_1}{\tan\alpha + n\mu}$$

while the total friction force is:

$$R = \frac{nP_1}{\tan\alpha + n\mu}$$

The torque that such an assembly can transmit is:

$$M = \frac{Rd}{2}$$

$$= \frac{nP_1\mu d}{2(\tan\alpha + n\mu)}$$

A nut, of the form shown in Figs. 4 and 5, is generally used to clamp the ring together. With three elements arranged as in Fig. 4:

$$\sum N = P_1 \frac{3\tan\alpha + 4\mu}{(\tan\alpha + 2\mu)^2}$$

For the assembly in Fig. 5:

$$N_1 = \frac{P_1}{\tan\alpha + 2\mu}$$

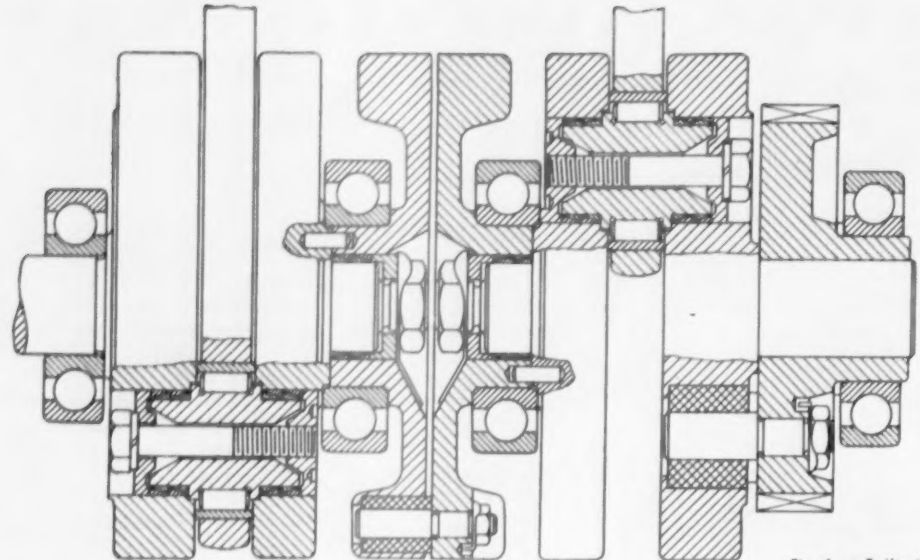
and $$\sum N = \frac{N_1(c^n - 1)}{c - 1}$$

where $c = \tan\alpha/(\tan\alpha + 2\mu)$. The friction force R does not increase in proportion to the coefficient of friction μ, but at a much lower rate shown in Table 1.

The value of the radial load N becomes progressively less, following a hyperbolic law from element to element. Thus, if N for one element is 100 per cent, it will be only 50 per cent for the second element and 25 per cent for the third element. Because of this it is advisable, for the transmission of heavy torques, to use two sets of rings, one at each end of the hub.

TABLE II.

d mm	D mm	l mm	Ultimate tensile strength, ton/in² 6·3 Torque lb-ft	6·3 Axial force P_1	12·6 Torque lb-ft	12·6 Axial force P_1	18·9 Torque lb-ft	18·9 Axial force P_1	25·2 Torque lb-ft	25·2 Axial force P_1
16	20	6·3	16·7	4,000	31·2	5,500	51·5	7,700	73	9,900
20	25	6·3	26·2	4,400	45	6,350	75	9,100	105	11,900
25	30	6·3	40·7	4,900	75	7,400	126	10,900	178	14,300
32	36	6·3	67	5,700	125	8,800	209	13,200	293	17,600
40	45	8	138	7,800	254	13,200	435	20,400	608	27,700
50	56	8	215	9,500	403	15,800	675	25,000	950	34,000
63	70	9	385	12,600	735	22,000	1,220	35,000	1,720	48,000
80	88	10	670	17,600	1,250	30,000	2,070	47,500	2,920	65,000
100	108	11	1,165	24,000	2,180	41,500	3,130	66,000	5,100	90,500
120	130	12	1,765	30,000	3,270	52,000	5,520	83,000	7,700	114,000
160	172	14	3,800	47,000	7,120	82,000	11,900	132,500	17,350	181,000
200	212	16	6,900	67,500	12,900	117,000	21,400	191,000	30,200	264,000
250	264	20	13,500	100,000	25,400	183,000	42,200	294,000	59,000	410,000



(e)

Fig. 6. e Built-up crankshaft

The dimensions, abstracted from the maker's list, of a number of ring elements for shaft diameters selected in accordance with the R10 preferred number series, B.S. 2045 : 1953, are given in Table II.

Typical applications of ring spring securing elements are shown in Figs. 6a, 6b, 6c, 6d and 6e. The method of using the rings to secure pulleys to shafts is illustrated in Figs. 6a and 6b respectively. Fig. 6c is an arrangement for securing a two-piece double-helical gear so that the two components can be manufactured separately. With applications such as this, which require careful adjustment of intermeshing of components on shafts and, for example, Roots type blower lobes, cams, brake levers, torsion bars and machine tool components, ring spring elements can be of considerable advantage. The use of ring springs for a quickly detachable coupling is shown at 6d. In this assembly, the circlip in the bore between the shafts ensures that the coupling is centralized relative to the ends of the shafts. The new device applied to built-up crankshafts is shown at 6e and similar arrangements have already been used in practice for single-cylinder compression-ignition engine crankshafts and for securing flywheels.

Recent Publications

Brief Reviews of Current Technical Books

Bearing Lubrication Analysis

By R. R. Slaymaker.

New York and London: J. Wiley and Sons Inc., New York; and Chapman and Hall Ltd., 37 Essex Street, W.C.2. 1955. 9 × 6. 108 pp. Price 40s.

This book, which deals with sleeve bearings, is written primarily for engineering college students whose main interest is machine design. However, the practising engineer who is not already familiar with the subject may find sections of the work useful. The first chapter is an introduction and occupies only four pages. After the second, which is on viscosity and other properties of oil, there are two more on hydrodynamic journal bearings. These two cover load-carrying capacity, friction torque, oil flow and temperature rise. Although hydrodynamic theory alone is not sufficient for the design and successful operation of bearings, an elementary understanding of it serves as a signpost to keep the designer on the right track. Chapter 5 gives examples of sleeve bearing design and chapter 6 is on materials, construction and bearing life. In chapter 7, boundary conditions and coefficients of friction are dealt with, as well as bearings that operate without an external supply of lubricant.

The book was written as a basis for a one-term graduate course at the Case Institute of Technology, U.S.A. It is purposely abridged to give the lecturer an opportunity to enlarge upon and augment the subject matter in the light of his own experience. For a subject such as this, to be taught in a short course, a discussion containing a solid text of fundamental thought appropriately applied is more to the point than would be a long treatise, much of which would have to be skipped in order to complete the work in the allotted time. Those who wish to specialize in bearing design or to become lubrication analysts will find that the material in this book is a firm foundation on which to build; and for those who simply wish to add bearing design to their repertoire, the text is adequate.

Automobile Electrical Equipment

By A. P. Young, O.B.E., M.I.E.E., M.I.Mech.E. and L. Griffiths, M.I.Mech.E., A.M.I.E.E.

London: Iliffe and Sons, Ltd., Dorset House, Stamford Street, S.E.1. 1956. 8¾ × 5½. 387 pp. Price 25s.

This is the fifth edition of the well-known book by A. P. Young and L. Griffiths, first published in 1933. It has been revised to include up-to-date details of flashing light direction indicators, electrical controls for overdrive systems, electrically-operated door gear, A.C./D.C. motor cycle lighting systems, dry-charged batteries, steel alkaline batteries and other recent developments. The work is more than a manual on components: it explains the fundamental principles underlying the design of each piece of equipment and these explanations are followed by the practical details. Clear diagrams and half-tone illustrations are used freely. This comprehensive method of treatment makes the book suitable for the motoring novice as well as experienced automobile electricians.

The first chapter deals with fundamental principles and it is followed by five more headed: The Complete Electrical Equipment, The Dynamo or Generator, The Starter Motor, The Battery, and Automobile Lighting. The thoroughness with which these subjects are dealt can be judged by the fact that under the heading Automobile Lighting, for example, the subjects discussed

include the principles of illumination, beam intensity, reflector theory, the dazzle problem, headlamp mountings and structure, and fluorescent lighting. These six chapters fill the first 207 pages of the book. The remainder of the work is devoted to ignition. This field is covered in nine chapters, which are headed: Electrical Ignition Systems; The Process of Ignition; The High-Tension Magneto; Magnetos; Magneto Installation; Impulse Starters And Automatic Timing Control; Radio Interference Suppression; Magnetizing And Timing a Magneto and, finally, Sparking Plugs.

Fifth Symposium (International) on Combustion

By The Combustion Institute.

New York and London: REINHOLD PUBLISHING CORPORATION, 430 Park Avenue, N.Y. 22; and CHAPMAN AND HALL LTD., 37 Essex Street, W.C.2. 1955. 10¼ × 6¾. 802 pp. Price 120s.

In this volume there are 101 papers of outstanding merit presented at the Fifth International Combustion Symposium held in 1954 at the University of Pittsburgh. It is the work of 182 contributors from many parts of the world and is of the highest technical standard. Since it undoubtedly is a useful work of reference for combustion specialists, scientists and chemists engaged in combustion research, it inevitably will also be appreciated by engineers concerned in a less specialized way with combustion in all types of engines. It is also of value to chemists and chemical engineers interested in the kinetics of oxidation, to metallurgists interested in the development of high-temperature-resistant materials, to physicists concerned with diffusion, heat transfer and fluid flow and to engineers studying combustion in rocket engines.

Forty-five papers deal with the subject of kinetics of combustion reactions; the remainder cover the combustion of fuel droplets, combustion of solids, propellant burning, special techniques and instrumentation, diffusion flames and carbon formation, flame spectra, dissociation energies and special processes in engines. In eleven papers by invited authorities, unsolved problems in various types of engines, and basic kinetic problems, including high-temperature kinetics, are discussed.

Automotive Transmissions and Power Trains

By William H. Crouse.

New York and London: MCGRAW-HILL BOOK CO. INC., 95 Farringdon Street, E.C.4. 1955. 9 × 6. 632 pp. Price 43s.

William H. Crouse, the author of this book, has a background of sound engineering training as well as practical industrial experience. Much of his experience has been gained with the Delco-Remy Division of the General Motors Corporation, where he was at one time director of field education. During the war years, he wrote a number of technical manuals for the armed forces. Subsequently, he became editor of Technical Education Books for the McGraw-Hill Book Co. The book under review is one of a series of five, some of which have already been reviewed in *Automobile Engineer*. This set is called the McGraw-Hill Automotive Mechanics Series and, as its name suggests, it is intended for service rather than design engineers. However, a great deal of information on the Gyro-matic, Hydra-matic, Powerglide, Fordomatic and Powerflite systems is included and this undoubtedly will be of interest to designers.

Principles of Farm Machinery

By Roy Bainer, R. A. Kepner and E. L. Barger.

New York and London: JOHN WILEY AND SONS INC., New York; and CHAPMAN AND HALL LTD., 37 Essex Street, W.C.2. 1955. 8¾ × 5¾. 571 pp. Price 70s.

In preparing this text book, the authors have aimed at the presentation of the subject of farm machinery from the engineering viewpoint. They have therefore placed emphasis on conventional requirements and principles of operation. Where practicable, machines for a particular cultural practice, such as planting, have been treated on the basis of unit operations performed by their functional elements. Methods of testing or evaluating the performance of certain types of field machinery are included.

The work is designed primarily as a text book for professional agricultural students, regardless of their expected field of subsequent specialization. Before reading the book, it is necessary for the student to have a knowledge of static mechanics, while an understanding of subjects such as strength of materials and dynamics would also be helpful. In the discussions of the machines, only a minimum amount of descriptive material has been included, since it is assumed that the reader is already familiar with the common types of farm machinery. However, for students who have not this background, useful lists of references are given in the appropriate sections of the book.

The subject matter deals primarily with the more common types of field machines, but also includes general discussions of materials, power transmission, economics and hydraulic controls, as applied to farm machinery. A chapter on seed cleaning is included because of its relation to the separating and cleaning functions in seed harvesting equipment. Unfortunately, space limitations have prevented the authors from considering many examples of special equipment, as well as localized special problems that require engineering attention and offer a real challenge to the farm machinery development engineer.

Lack of standardization of nomenclature is one of the difficulties confronting anyone writing about farm machinery. The authors have given considerable thought to this problem in an attempt to select the most descriptive and logical terms. Perhaps this work will contribute in some degree to future standardization of nomenclature. However, since the work is American in origin, some of the terms doubtless will be unfamiliar to British agricultural engineers.

Fibreglass Reinforced Plastics

By Ralph A. Sonneborn and others.

New York and London: REINHOLD PUBLISHING CORPORATION, 430 Park Avenue, N.Y. 22; and CHAPMAN AND HALL LTD., 37 Essex Street, W.C.2. 1954. 8¾ × 5¾. 240 pp. Price 36s.

During the past ten years, Fibreglass reinforced plastics has become a significant material in many manufacturing applications. Because of the rapid growth of the industry, the fund of knowledge that has been accumulated has been hitherto largely unconsolidated. This book has been written with a view to presenting as much of the available data as possible in a compact form, suitable as a work of reference for engineers and others concerned with the subject. It covers in detail the resins and glass reinforcement used, as well as moulding techniques, properties, design considerations, inspection and testing. Of special interest are two chapters contributed by leading authorities in engineering research. The first, which is by Professor A. G. H. Dietz, head of the department of structural materials at the M.I.T., discusses the theory and fundamental concepts of reinforced plastics. The second, by A. S. Heyser of Reed Research Inc., deals with design from the viewpoint of the hydraulic engineer.

In part I of the book, chapters 1 and 2 deal respectively with the nature and use of Fibreglass reinforced plastics, and materials. The next three chapters cover manufacturing processes, secondary operations, and inspection and testing. Finally, in part I, there are three chapters in which properties, design methods, and applications are discussed. Part II comprises the contributions by the two research authorities and is followed by appendices giving a glossary of terms and a selected bibliography.

Modern Petrol Engines

By A. W. Judge.

London: CHAPMAN AND HALL LTD., 37 Essex Street, W.C.2. 1955. 9½ × 6. 564 pp. Price 56s.

This is the second edition of this work, which was first published in 1946. It deals with automobile, marine, aircraft and stationary high-speed petrol engines and is written for the designer, engineer, draughtsman and student. The latest edition includes an appreciable amount of new material relating to recent developments in petrol engine research and application. This information includes up-to-date facts about detonation research, combustion chamber design and alternative fuels for petrol engines. Additional details of the properties of modern engine lubricating oils are also given.

Carburettors and the Fuel System

By E. P. Willoughby, B.Sc., M.I.Mech.E.

London: TEMPLE PRESS LTD., Bowling Green Lane, E.C.1. 1954. 7½ × 5. 56 pp. Price 2s.

The Modern Car Easy Guide Series is well known and needs no introduction. This booklet is the fifth of the series and is now in its fourth edition. The author's aim has been at including items of real importance and omitting all that are not. The work is written in simple language for normally intelligent persons having little or no practical knowledge of the subject. Its main value is its compactness: the reader does not have to waste time studying details that are unlikely to interest him.

New Barium Titanate Transducers

G.E.C. Accelerometers and Strain Gauges for Vibration Testing

THE Research Laboratories of The General Electric Co. Ltd. have now developed miniature barium titanate accelerometers and strain gauges which are already proving extremely useful in the field of vibration testing. They are new devices, the first of their kind to be made available on a large scale in this country, and they have many advantages over older methods of vibration detection and measurement. They are inexpensive, reliable and simple to operate, and their very small size enables them to be used in a variety of circumstances where it would be impossible to accommodate more bulky equipment. In addition they are extremely sensitive and will work efficiently over a relatively wide range of temperatures and vibration frequencies.

Barium titanate transducers have applications in many branches of engineering, in the manufacture of aircraft, cars, armaments and electronic equipment, as well as in other less obvious fields such as the transport of packaged goods where vibration may be experienced.

Principles of operation

Substances of the barium titanate type are classed as ferroelectric materials; that is to say they can, by the application of a large D.C. voltage, be permanently polarized electrically rather as a ferromagnetic material such as iron can be polarized magnetically. When properly prepared and polarized barium titanate behaves as a piezoelectric crystal with a very high activity. When such a crystal is compressed, the strain in the crystal gives rise to a minute potential difference across the faces which is proportional to the degree of compression. Conversely, if a potential difference is applied to those faces, the crystal itself will suffer a very small decrease in size.

When subjected to repeated alternating compression and expansion a piezoelectric crystal will generate an electrical charge proportional to the forces being applied to it. This is what happens in an accelerometer, where the crystal is fixed between a rapidly vibrating surface and an inertia weight. The electrical charge is fed to a detector with a suitably high impedance, such as a cathode follower, and the signal can then be observed on a cathode ray oscilloscope. This method gives the frequency and amplitude of the vibrations. The barium titanate strain gauge is a more simple device consisting only of a barium titanate crystal with two leads attached. In this case resonant frequencies can be determined in vibrating mechanical structures, as well as the approximate relative strengths of such vibrations. The great sensitivity of barium titanate transducers depends on the material's very high dielectric constant and piezoelectric activity, which are considerably greater than those of quartz.

Construction and Operation

The first of the new devices is the G.E.C. Type E barium titanate accelerometer, which can detect and measure shocks and vibrations on any object or mechanism over a wide range of operating conditions. It consists of a circular disc of barium titanate about $\frac{1}{8}$ in thick and $\frac{5}{8}$ in in diameter, which is silvered on both sides and sandwiched between two pieces of brass. One piece forms the base and is terminated by a 2 B.A. stud for fixing purposes. The other acts as an inertia weight which converts the vibrations in the equipment to strains in the ceramic. These strains then generate a piezoelectric charge, proportional to the acceleration applied to the base, which is collected by a coaxial screened cable. The signal is taken to a detector with a suitably high impedance such as a cathode follower, and can be observed on a cathode ray oscillograph. The accelerometer is only $\frac{3}{4}$ in long, and can easily be attached by its stud to any piece of equipment whose vibration characteristics are to be studied. It is simply and strongly constructed, yet weighs only 11 grammes (18 grammes with screening-can), so that the loading effects on the apparatus under test are minimized. The response of the accelerometer to accelerations of up to 1000 g is linear and its charge sensitivity of about 5 pC/g gives a voltage output of about 20 mV/g using conventional circuitry (g = gravitational constant). The accelerometer will detect and record frequencies in the range 20 c/s to 20 kc/s, and between 40 c/s and 10 kc/s it is accurate to within ±10 per cent. An important design feature of the G.E.C. accelerometer is the construction of the base, which is reduced in thickness just above the mounting stud. This is most effective in reducing spurious signals due to strains in the object under test, and it also reduces the effect of transverse accelerations. The transverse sensitivity of the device is less than 5 per cent of the axial sensitivity, so that the direction of vibration can readily be determined by the position in which the unit is mounted.

Operation of the accelerometer is effective at any temperature between —50 degC and +100 degC; if this temperature is exceeded the piezoelectric properties can be restored by repolarization. The voltage sensitivity varies with temperature to the extent of only 0·15 per cent per degree Centigrade. Each unit is individually calibrated at a particular temperature and is supplied with a 32 in length of screened cable.

For certain applications it may be preferable to use a screened accelerometer. A screened version of the Type E unit has therefore been designed, with a performance very similar to that of the unscreened type. The aluminium screening-can makes the device somewhat larger, measuring $\frac{5}{8}$ in by $1\frac{1}{8}$ in.

The G.E.C. vibration strain gauge was originally developed for measurements of blade vibrations on rotating turbine wheels but it has many other applications to similar problems. It is two or three thousand times as sensitive to alternating strain as a typical wire resistance strain gauge, but does not respond to steady strain.

The gauge consists of a thin bar of polarized barium titanate with silver electrodes on the two major faces. The electrode on the lower face is extended round one edge on to a small part of the upper face and the leads are soldered on to the two electrodes on the upper face. The under side of the gauge is attached to the object to be tested by a suitable cement. When the object vibrates, the alternating strains in the plane of the gauge produce an alternating charge on the electrodes, which is fed to a suitably high impedance detector. Unlike the accelerometers, the strain gauges are not supplied calibrated, because they are intended primarily for the determination of the various frequencies at which resonant vibrations occur in mechanical structures, and also of the approximate relative strengths of such vibrations. They will operate in the frequency range 20 c/s to 50 kc/s.

An important feature of the barium titanate strain gauges, not possessed by other types of gauge, is that they can be used either to detect vibrations or to excite them by the reverse process of applying an alternating voltage to the crystal. This considerably increases the scope of vibration measurements which can be made on mechanical structures.

The strain gauges are made in two standard sizes, measuring $\frac{3}{4}$ in $\times \frac{1}{4}$ in $\times$ 0·035 in and $\frac{3}{8}$ in $\times \frac{1}{8}$ in $\times$ 0·035 in, either of which can be used for detection or excitation. The sensitivity is of the order of 0·1 volts output for an alternating displacement of 1 part in 10^6.

Steering of Multi-Wheel Vehicles

The Heumann Minimum Method for Determining the Position of the Centre About Which a Vehicle Turns

CREDIT for the evolution of the science of flange force determination and of the methods of exact graphical analysis is mainly due to Prof. H. Heumann who, starting with the well-known *minimum rule*[1] developed this branch of graphical mechanics to a high state of perfection. Although the principles are of particular value for use in connection with complicated wheel arrangements on locomotives, they are also applicable to road vehicles. Motion of a vehicle round a curve can be regarded as a rotation about a vertical axis, combined with a motion of the vehicle parallel to its original position. In other words, on a curve, the motion of an axle and wheel assembly without a differential consists partly of pure rolling and partly of slip across the road.

The rotation takes place about a pole O, which can be called the centre of friction, and the position of which can be determined by the Heumann Minimum Method. Each wheel carries a load Q and offers a resistance $Q\mu$ to rotation about O, where μ is the coefficient of friction between road and wheel. The moment required to maintain rotation about O is $Q\mu\Sigma q$, where Σq is the sum of all distances between O and the point of wheel-to-road contact on one side of the vehicle, Fig. 1. A transverse force P, generally applied at the front wheels but sometimes at some other point, effects the rotational component of the motion. This force determines the direction of vehicle motion and is termed the *directional force*. The relationship between these quantities are given by :

$$Q\mu\Sigma q = Px$$

where x is the distance between the point of application of P and the pole O.

In the case of a vehicle with a rigid frame and n rigid axles, the moment about O is :

$$Px = \mu Q\Sigma_1^n 2q = M \tag{1}$$

the transverse, or directional, force is :

$$P = \mu Q\Sigma_1^n 2 \cos\beta \tag{2}$$

The first derivative of (1) with respect to x is :

$$\frac{dM}{dx} = P \times 1 + x\frac{dP}{dx}$$

$$= 2\mu Q\sum_1^n\frac{dq}{dx} \tag{3}$$

Introducing (2) in (3) :

$$2\mu Q\sum_1^n \cos\beta + x\frac{dP}{dx} = 2\mu Q\sum_1^n\frac{dq}{dx} \tag{4}$$

On the other hand, from Fig. 1, it can be seen that :

$$\cos\beta_n = x_n\sqrt{x_n^2 + s^2},$$

$$q_n = \sqrt{x_n^2 + s^2}$$

and

$$\frac{dq_n}{dx} = \frac{x_n}{\sqrt{x_n^2 + s^2}}$$

Furthermore :

$$\cos\beta_n = \frac{dq_n}{dx_n}$$

and

$$\sum_1^n \cos\beta = \sum_1^n\frac{dq}{dx}$$

Consequently, (4) can be re-written :

$$x\frac{dP}{dx} = O$$

Since the distance x cannot be equal to zero :

$$\frac{dP}{dx} = O$$

This means that pole O must be in such a position that the directional force P is of minimum value. This is Heumann's Minimum Rule.

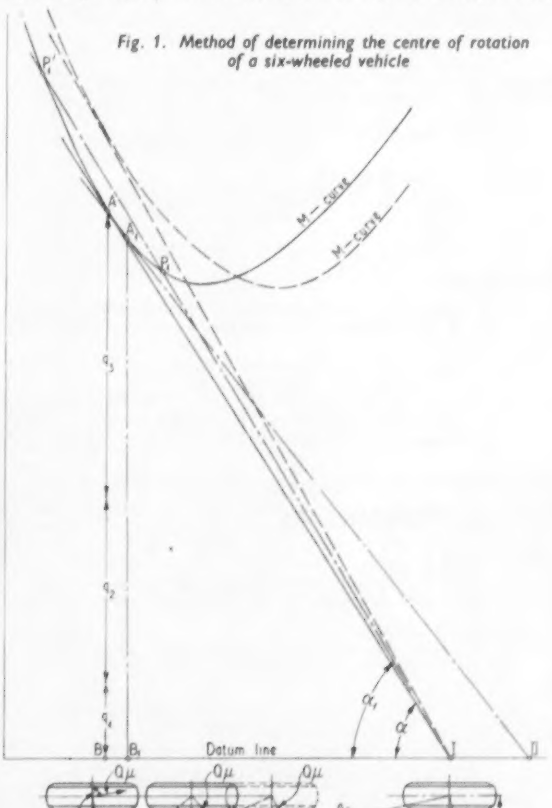
The method of determination of the position of the pole O for a six-wheeled vehicle is illustrated in Figs. 1 and 2. If, as in Fig. 1, the wheels and axles are positively located relative to the frame, that is, they are not steered, the magnitude of the moment $M = 2Q\mu(q_1 + q_2 + q_3)$ can be determined for any position of O by plotting the values of $q_1 + q_2 + q_3$ vertically above an arbitrary datum line, Fig. 1. By assuming that the value of $2Q\mu$ is unity, the entire area between the datum line and momentum curve can be regarded as the momentum area. The magnitude of the directional force P in units of $2\mu Q$ is :

$$P = \tan\alpha = (\Sigma_1^n q)/x$$

Since the M-curve is plotted for $2\mu Q = 1$:

$$P = 2\mu Q(\Sigma_1^n q)/x$$

Fig. 1. Method of determining the centre of rotation of a six-wheeled vehicle



For the case under consideration :

$$P = 2Q\mu(q_1 + q_2 + q_3)/x$$
$$= M/x = \tan \alpha$$

In Fig. 1, the maximum value of the moment M is at P_1, the point at which the line at an angle α_1, with its apex at the front axle, intersects the M-curve. The corresponding pole O is obtained by dropping, from the point of intersection, a perpendicular to the centreline of the vehicle, Fig. 1. An extension of the line α_1 bisects the M-line again at P_1'. This suggests, contrary to practical experience, that the vehicle might rotate intermittently about two poles. Consequently, if theory and practice are to be in agreement, the angle must be reduced from α_1 to α, at which angle the line from I becomes a tangent to the M-line. Since the value of $\tan \alpha$ is a minimum, the directional force, determined from AB/x or $P = \tan \alpha \times 2Q\mu$, also becomes a minimum. This again is Heumann's Minimum Rule.

From Fig. 1 it can be seen that, if P is applied at the front axle, its minimum value is obtained when the pole O is slightly in front of the rear axle. If the intermediate axle is mid-way between front and rear ones, as shown by the dotted lines, the pole remains virtually in the same position. Moreover, if the directional force P is applied ahead of the front axle at point II, then O moves further forward, the value of P being given by A_1B_1/x_1.

So far as steering layout is concerned, a six-wheeled lorry can be regarded as a four-wheel bogie, together with a free front axle at which the directional force is applied. In Fig. 2, the M-curve is plotted, as in Fig. 1, for a rear bogie without differentials on the axles. In this case, the pole is just ahead of the rear axle, but for a vehicle incorporating axle differentials as well as a differential between the rear axles, the behaviour of the vehicle is independent of s. Because of this, the M-curve is represented by a straight line at the distance a, equal to the rear wheelbase, above the datum line. At each end of the wheelbase the line turns up with a slope of 2 : 1. In these circumstances, the pole O' is at the rear axle.

If the inter-axle differential is not fitted, the term s has to be re-introduced as s_1, as shown in Fig. 2, but it is much smaller and its value varies with the turning circle. As a result, the M-curve closely follows that obtained for a vehicle with a third differential and the pole O is slightly forward of the rear axle. The value of the force P is given by the equation :

$$2Q\mu a = P(a + b)$$

An important feature of Fig. 2 is that, for a six-wheeled vehicle, the pole O is close to the rear axle and not, as is generally assumed, half-way between the rear axles.

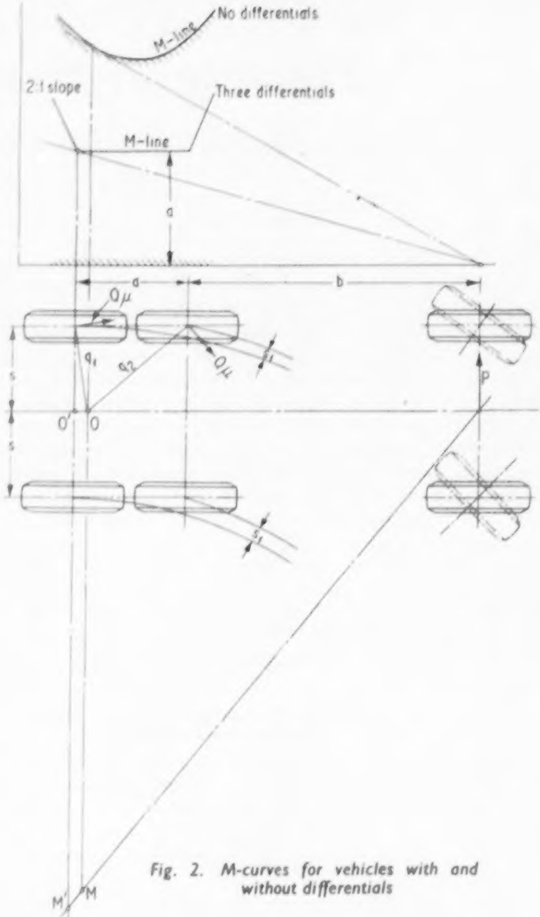


Fig. 2. M-curves for vehicles with and without differentials

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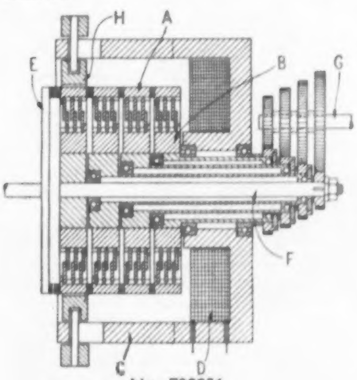
CURRENT PATENTS

A REVIEW OF RECENT AUTOMOBILE SPECIFICATIONS

Electromagnetic gear unit

THIS mechanically controlled electromagnetic gearbox has no slip ring or rotary contactor and need not be disengaged when changing ratio. It comprises a plurality of multi-plate clutches of the type which forms the subject of an earlier patent, No. 629311. Each clutch has two interengaging series of plates, axially slidable in driving connection with a common outer annulus A and with individual inner annuli B respectively. They are accommodated coaxially within a stationary, annular electromagnet C, in the closed end of which is housed the energizing coil D.

The outer annulus consists of clutch rings of magnetic metal spaced by rings of non-magnetic metal and secured to a driving disc E attached to the input shaft. Inner annuli are rigidly mounted respectively on a central solid shaft F and concentric tubular shafts, each running in a pair of ball or roller bearings. At their extremities, outside the electromagnet, these shafts carry fast pinions in constant mesh with gear wheels keyed to the output shaft G.



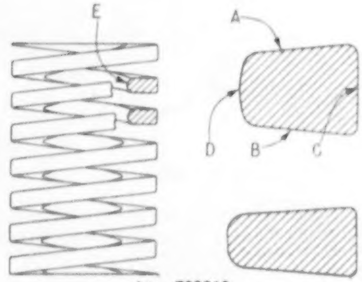
No. 729831

In the annular space between the outer annulus A and the electromagnet C is an axially slidable ring H of magnetic metal which can be shifted, either manually or automatically, by means of a pivoted selector fork. The actuating pins of this fork pass through arcuate slots in the magnet and are engaged in a peripheral groove in the ring. When ring H is coplanar with one of the clutch rings, that unit is engaged and the drive ratio is determined by the corresponding gearing at the output end. The other clutches rotate freely. If the ring is positioned intermediately between two clutch rings a braking action will result, the gearbox acting as a transmission brake.

Driving disc E may serve as a flywheel or as a component part of an alternator supplying electrical energy to the magnet coil and, alternatively or additionally, to the ignition or lighting systems. *Patent No.* 729831. *S. A. André Citroën (France).*

Helical Springs

IMPROVEMENT in helical springs is claimed for the use of a wire section that is substantially D-shaped after coiling. By arranging the convexly curved edge of the wire at the inner periphery of the spring, local concentration of stress is reduced and, in consequence, the fatigue life of the spring is extended.



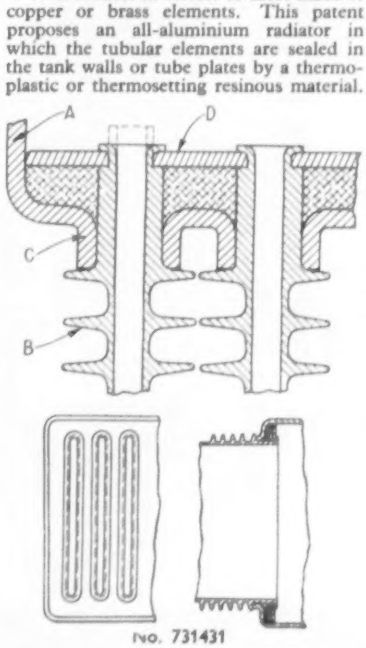
No. 732313

The wire stock from which such springs are manufactured is of a modified keystone section, as shown in two examples. Upper and lower faces A and B and outer edge C are straight. The inner edge C is composed of a central arc D of large radius, joined to the straight faces by arcs of lesser radius.

In the manufacture of springs, the wire is advanced through forming and upsetting roll dies to produce in the coiled spring a section having parallel faces, and a perpendicular outer edge. The inner edge is convexly semi-circular to a radius struck from the medial plane between the parallel faces. *Patent No.* 732313. *Eaton Manufacturing Co. (U.S.A.).*

Plastics sealed, light alloy radiator

WHILE radiators and oil coolers of aluminium alloy have been built for aircraft applications and other special purposes, they have not been adopted for automobile use since they cannot be produced by conventional methods and have not proved to be as reliable in service as those made of copper or brass elements. This patent proposes an all-aluminium radiator in which the tubular elements are sealed in the tank walls or tube plates by a thermoplastic or thermosetting resinous material.



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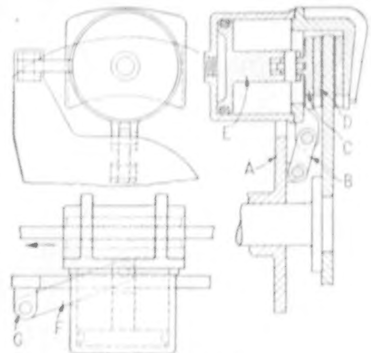
Silicone rubber, silicone resin, or nylon are mentioned as suitable.

Header tank A and the bottom tank are connected by flat tubular finned elements B, the ends of which are entered in suitably shaped orifices in the tank walls. Each orifice is outwardly flanged, as at C, and the edge of the flange is seated on the end fin of the tube B. Should plain tubes be used a collar or shoulder is provided to form a seating. The tube extends a certain distance through the orifice into the interior of the tank and at its extremity is reduced in diameter to leave a shoulder to support a cover plate D which extends over the entire area of the tank.

The space intervening between tank wall and cover plate is filled with plastics material which under the application of pressure on the cover plate and simultaneously heating to an adequate temperature, bonds all the parts together into a single unit. Subsequently, the projecting ends of the tubular elements are rolled over to permanently secure the cover plate. *Patent No.* 731431. *Ustav pro Vyzkum Motorovych Vozidel and V. Balik. (Czechoslovakia).*



No. 730053

Self-energizing disc brake

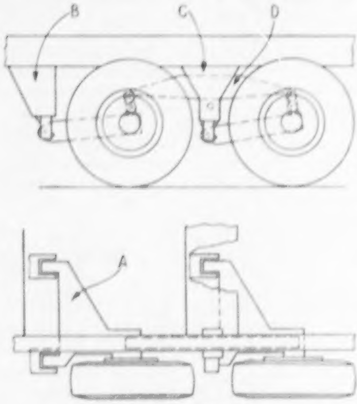
IN a spot-type disc brake the piston-actuated frictional element is pivotally anchored by a linkage arranged to impart a self-energizing action. The cylinder of the fluid-pressure actuating mechanism is supported from a carrier plate A by means of a link B pivoting in a plane normal to the brake disc and intersecting its axis. A pressure plate C carrying a pad of friction material D is pivotally connected to the bifurcated end of piston rod E and on the other side of the disc a similar friction pad is mounted on the plate of the yoke. To the piston rod pivot pin is also connected a link F anchored on a lug G on an extended arm of the carrier plate.

When the brake is actuated by the application of fluid pressure, pressure plate C and pad D tend to move in the same circumferential direction as the brake disc. Link F is subjected to a compressive force, the reaction to which may be resolved into two component forces respectively parallel to and normal to the brake disc. The component normal to the disc augments the force exerted by the pressure fluid to apply braking effort. *Patent No.* 730053. *Clayton Dewandre Co. Ltd.*

Tandem wheel suspension

WHEN vehicle brakes are applied, the vertical reaction between the ground and a wheel mounted on a longitudinally arranged link is varied. The reaction is increased in the case of a leading link and decreased if the link is of the trailing type. In suspension units comprising four wheels arranged two in tandem on each side of the vehicle, it is not uncommon for the tandem wheels to be mounted respectively on leading and trailing links. Such an arrangement results in the phenomenon of load transference by braking, which the invention aims to obviate.

By arranging the links of a tandem pair of wheels to be both of the same type, the reaction effects will be the same on each wheel and may be cancelled out by the usual compensating beam. The example shows tandem wheels independently mounted on carrier arms A pivoted on



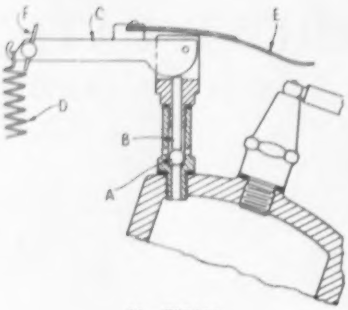
No. 732634

brackets B and C depending from the vehicle frame. Brackets C have additional pivot bearings for the rocking beam D which may be either a rigid beam or a leaf spring. The ends of the beam may be shackled to the carrier arms or may be provided with a suitable sliding connection. Resilient blocks may be incorporated at the centre pivot or at the ends of the beam to minimize the transmission of road shocks. *Patent No.* 732634. *Multiwheelers (Commercial Vehicles) Ltd. and G. Machray.*

Braking two-stroke engine

THE braking effect of a two-stroke engine is very slight as compared with that of a four-stroke engine and, therefore, in long descents a two-stroke engine cannot be used to augment the wheel braking system. To overcome this handicap the invention provides a valve device by which the ignition is short-circuited and a partial vacuum is formed in the cylinder at each revolution. In a body screwed into the cylinder head a ball valve A is, during normal running, held tightly to its seating by a plunger B and the cam-shaped end of a lever C constrained by a spring D. On the lever is mounted an earthing contact spring E, the end of which is located adjacent to the spark plug terminal.

When lever C is raised by means of a rod or cable control F the plunger B is released to permit free operation of ball valve A and contact E short-circuits the ignition. Thereafter, outward movement of the piston forces the contents of the cylinder through the restricted valve orifice and inward movement seats the ball and creates a partial vacuum in the cylinder.



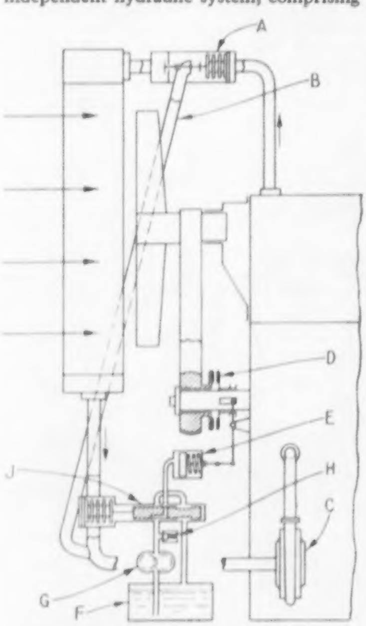
No. 732616

In an alternative arrangement the braking valve and the spark plug are both mounted in an adaptor screwed into the cylinder head. *Patent No.* 732616. *Schneto A.G. (Switzerland).*

Engine cooling system

FOR the major part of a vehicle's operating time under normal conditions the air stream engendered by forward movement and passing through the radiator is sufficient to ensure an adequate transfer of heat from the coolant. Under these conditions the radiator fan becomes redundant. The invention proposes to control automatically the operation of the fan to avoid the waste of power in driving it and also to prevent over-cooling of the engine.

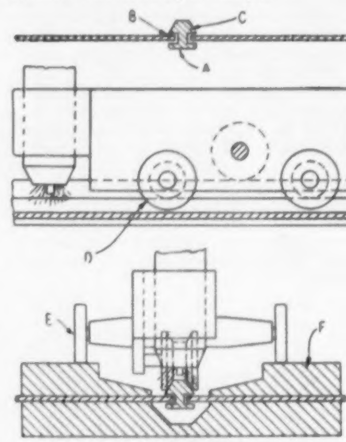
In an otherwise conventional system having a thermostatic control A and by-pass B for a direct return to circulating pump C, the radiator fan is belt-driven from the end of the camshaft through a clutch D. The clutch is operated through a lever linkage by the piston of a fluid-pressure cylinder E. A spring mounted behind the piston tends to hold the clutch in the inoperative position. The admission of pressure fluid, which may be lubricating oil, displaces the piston and brings the clutch into frictional engagement to drive the fan. Pressure fluid is supplied by an independent hydraulic system, comprising



No. 732044

a tank F, engine-driven pump G and pressure relief valve H, which is under the control of a thermostatically actuated valve J.

The capsule type thermostat, located in the return pipe from the base of the radiator, is normally in the contracted condition, holding valve J to the left, recirculating the oil to tank F, and rendering the fan inoperative. After a start from cold, when the by-pass is cut by valve A the coolant continues through the radiator which is unassisted by the fan. Only when the air stream induced by travel is inadequate and the temperature of the coolant leaving the radiator exceeds a predetermined value does valve J open to admit fluid to cylinder E and bring the fan into operation. *Patent No.* 732044. *Daimler-Benz A.G. (Germany).*



No. 732635

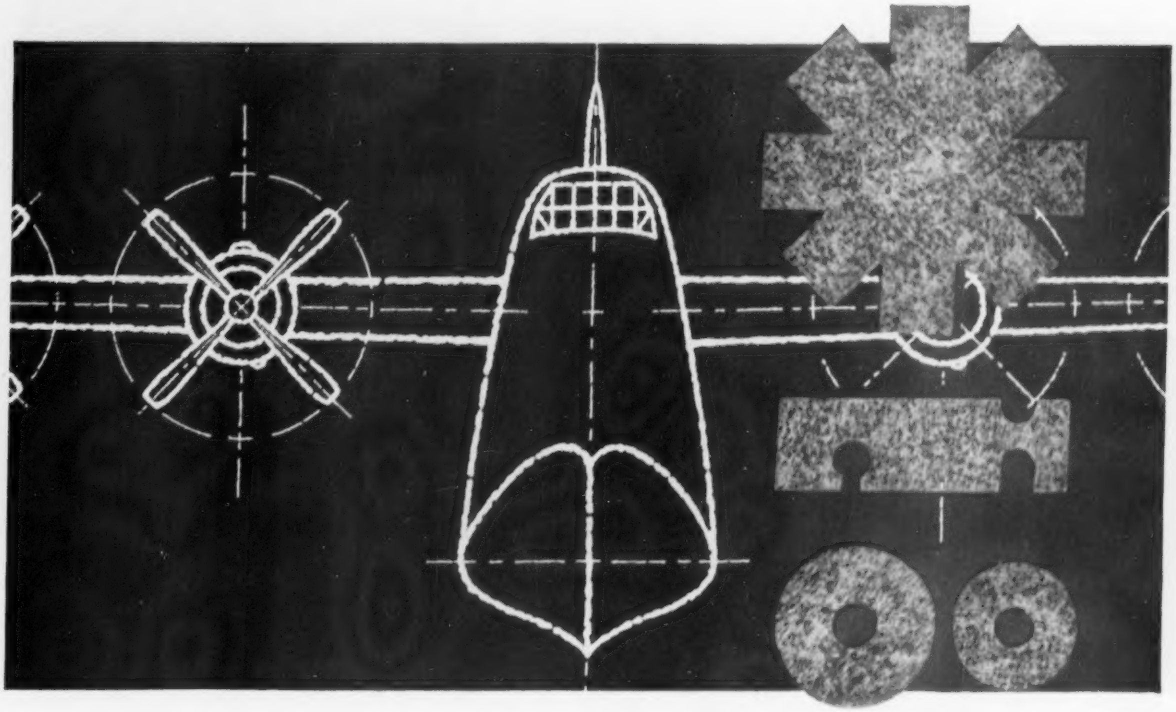
Long seam welds in light alloy panels

WHEN welding together long sheets of light alloy, for example the side panels of passenger or commercial vehicle bodies, there is a tendency for the edges to distort under the localized heat and to separate. It is usually necessary to clamp the parts in position and some adjustment may have to be made on completion of the work. Additional metal must be supplied by welding rods and, if the work is to be performed automatically, a guide must be provided.

By the expedient of forming the welding rod as an extruded section A, the sheets can be located in lateral grooves B and the welding machine guided on the profiled head C of the rod. In the illustration is shown a clamping fixture that provides a track for the welding apparatus and also serves to conduct heat away from the seam. The welding head carriage has guide rollers D which position the burner accurately over the extruded rod and stabilizing rollers E which run on the clamp rails F. The carriage may be moved by hand or propelled by a variable speed motor.

The extruded rod may be of any suitable section providing it has two grooves to receive the sheets. These grooves may be arranged in different planes or at angles up to 90 deg. If desired the channel in the fixture below the seam may be shaped to serve as a mould for the fused metal or it may be used to conduct argon gas if the weld is to be made by an argon arc process. *Patent No.* 732635. *Société Anonyme pour l'Industrie de l'Aluminium (Switzerland).*

Saunders-Roe use the **Meadowfelt** service



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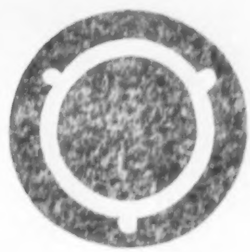

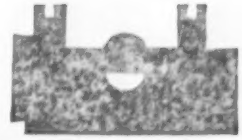

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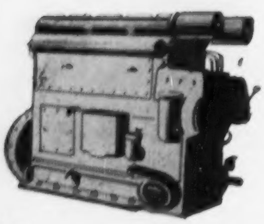

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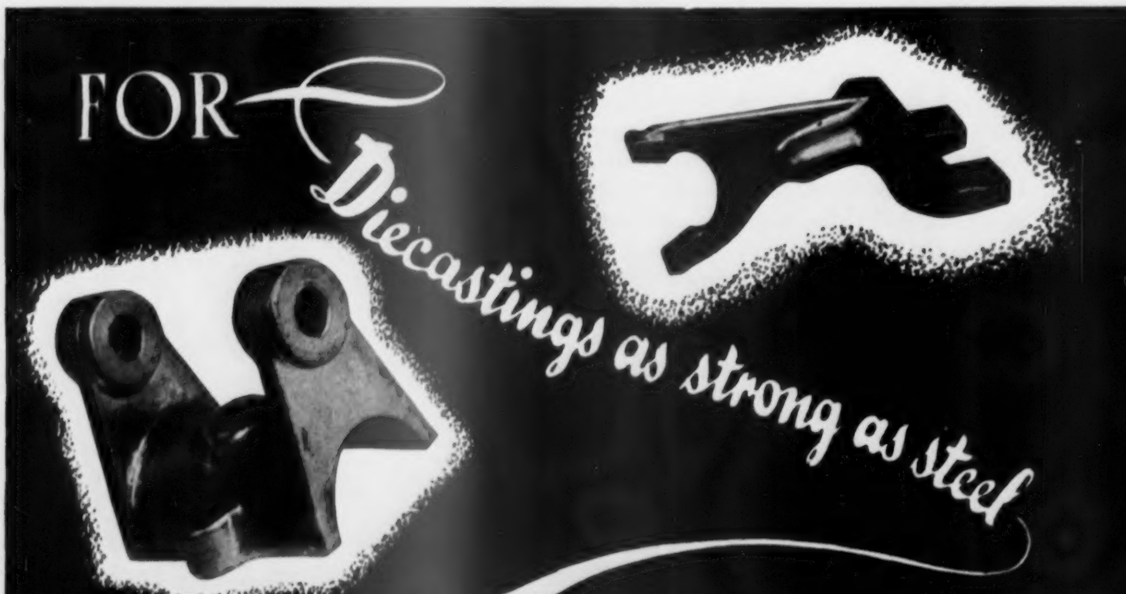

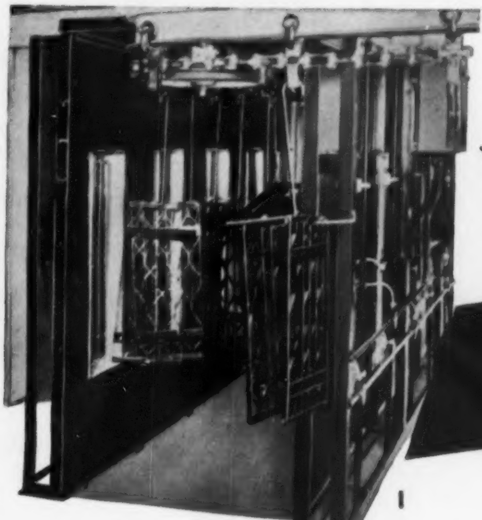

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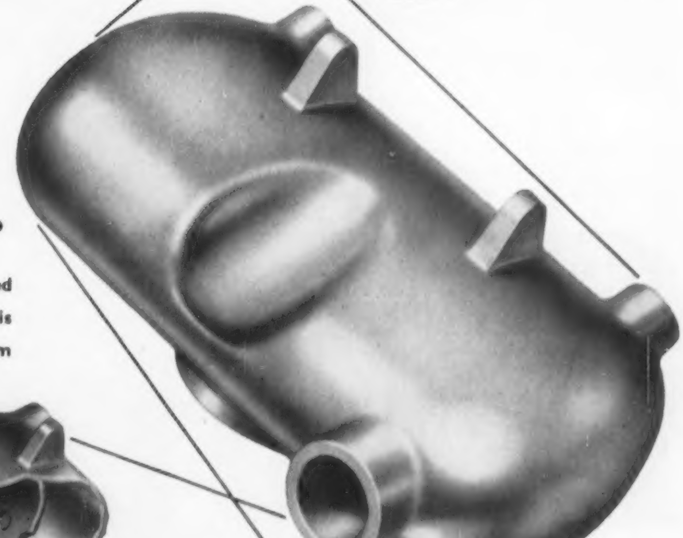

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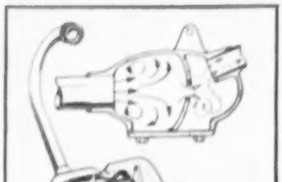

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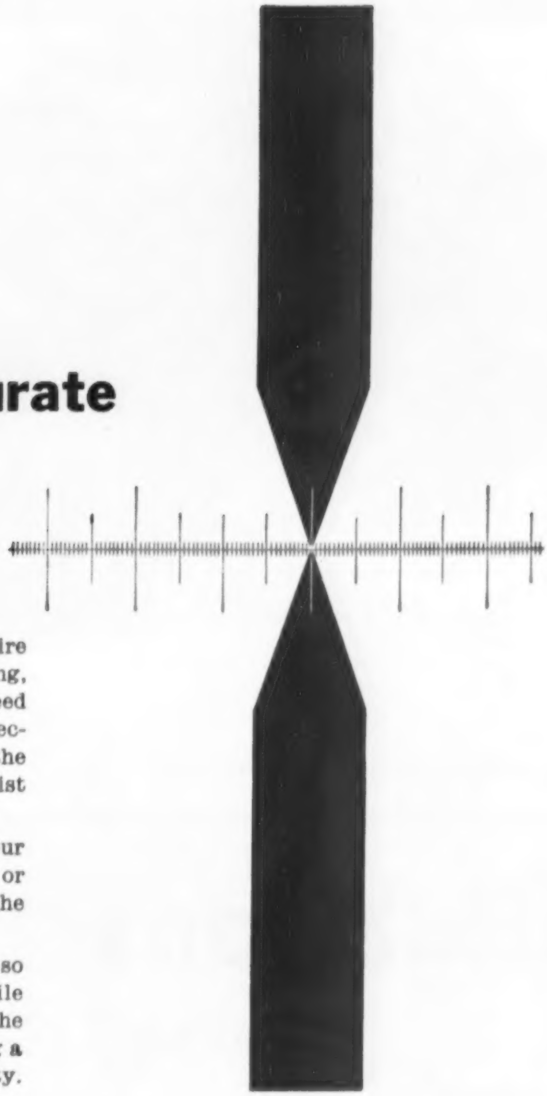

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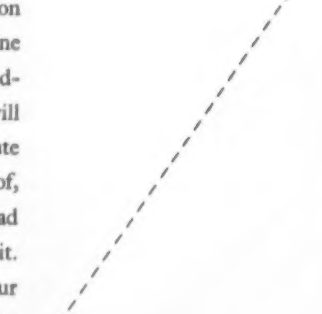

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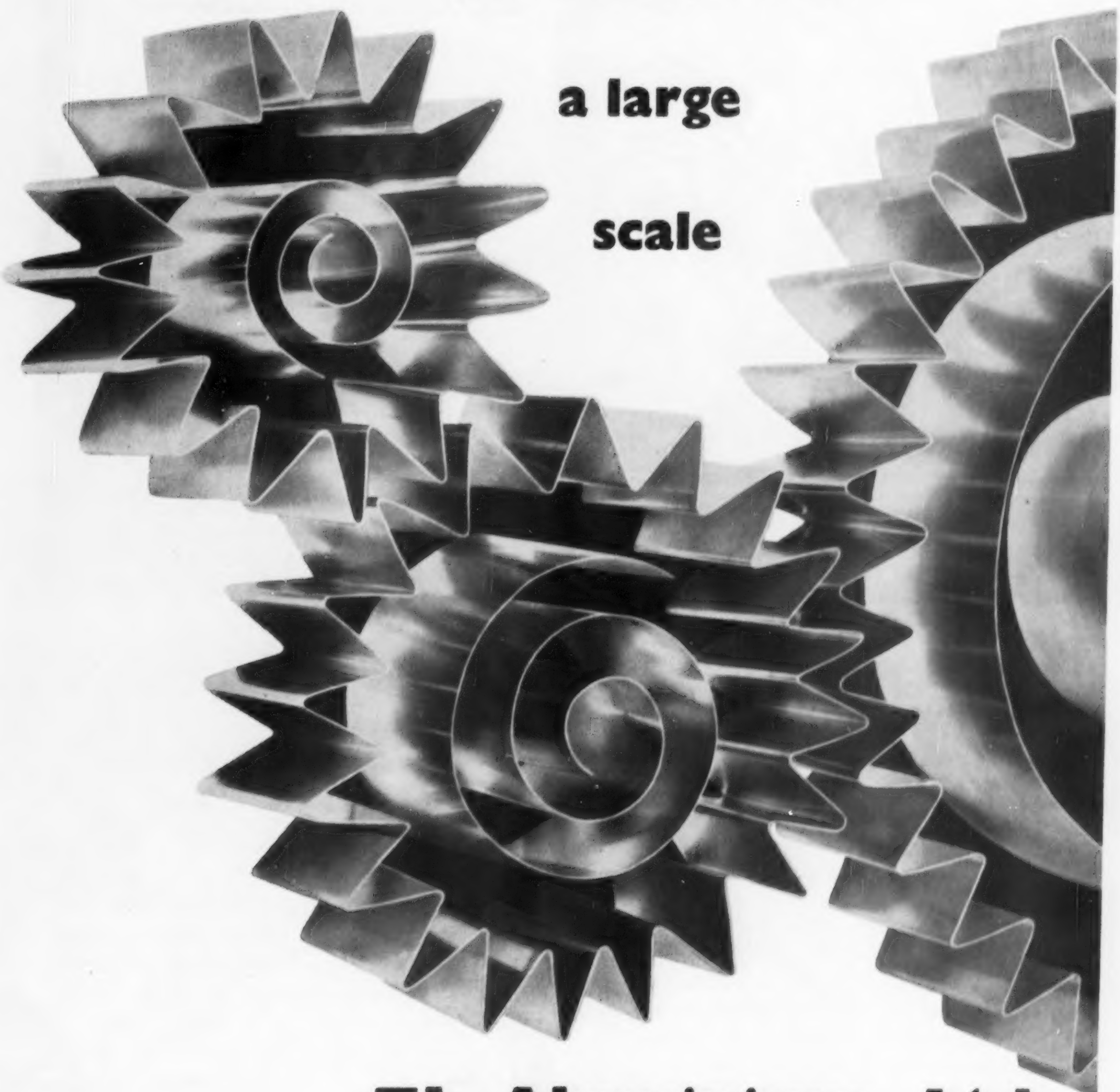

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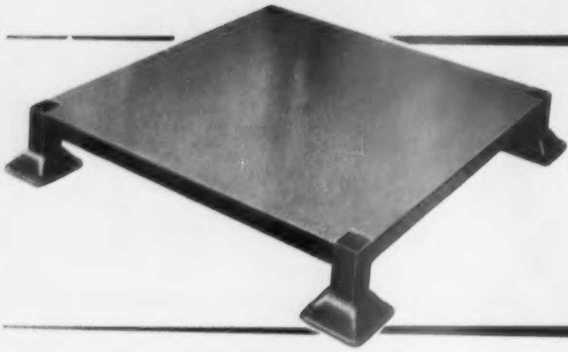

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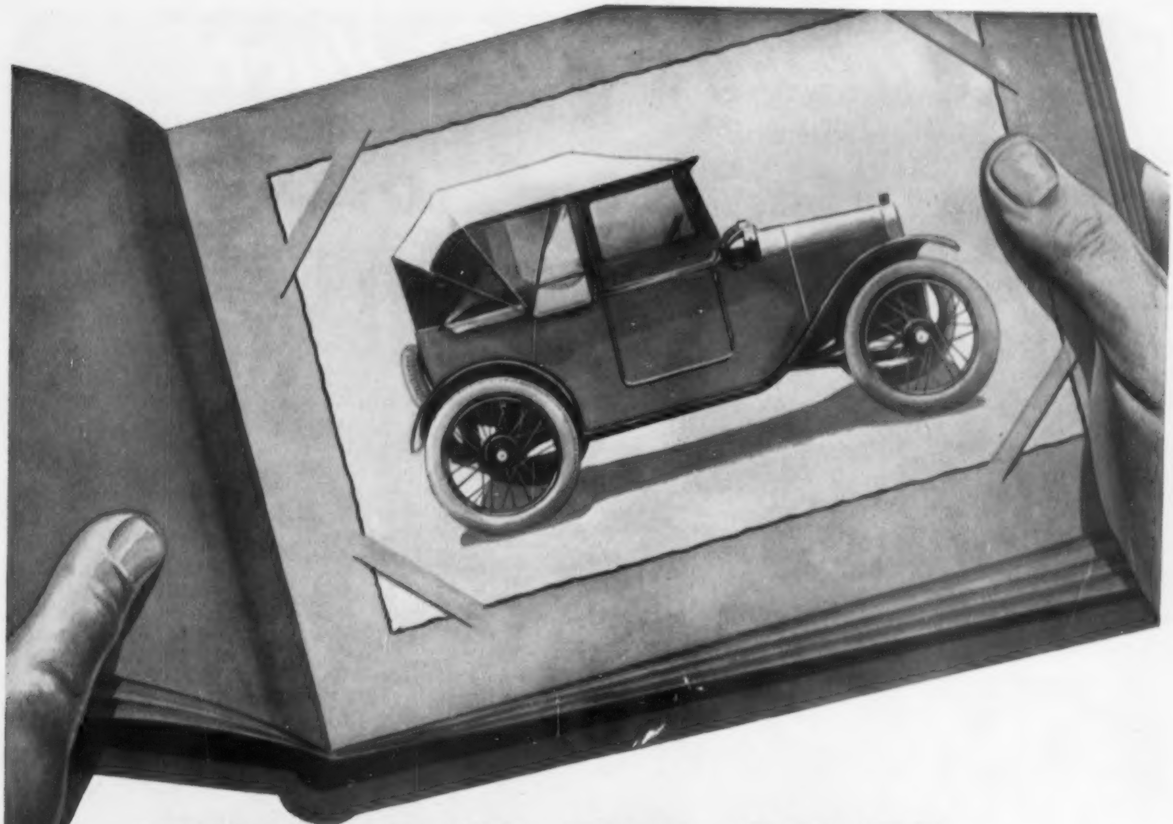

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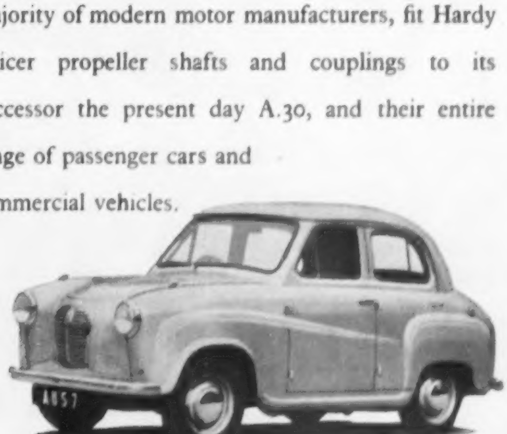

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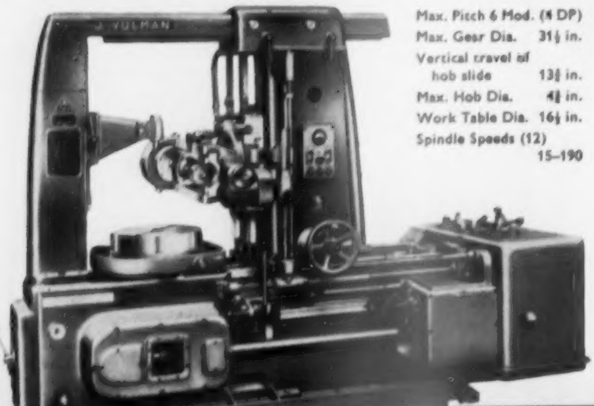

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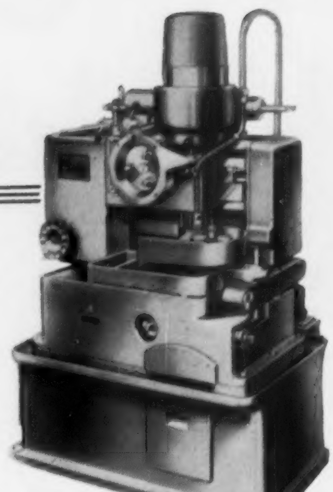

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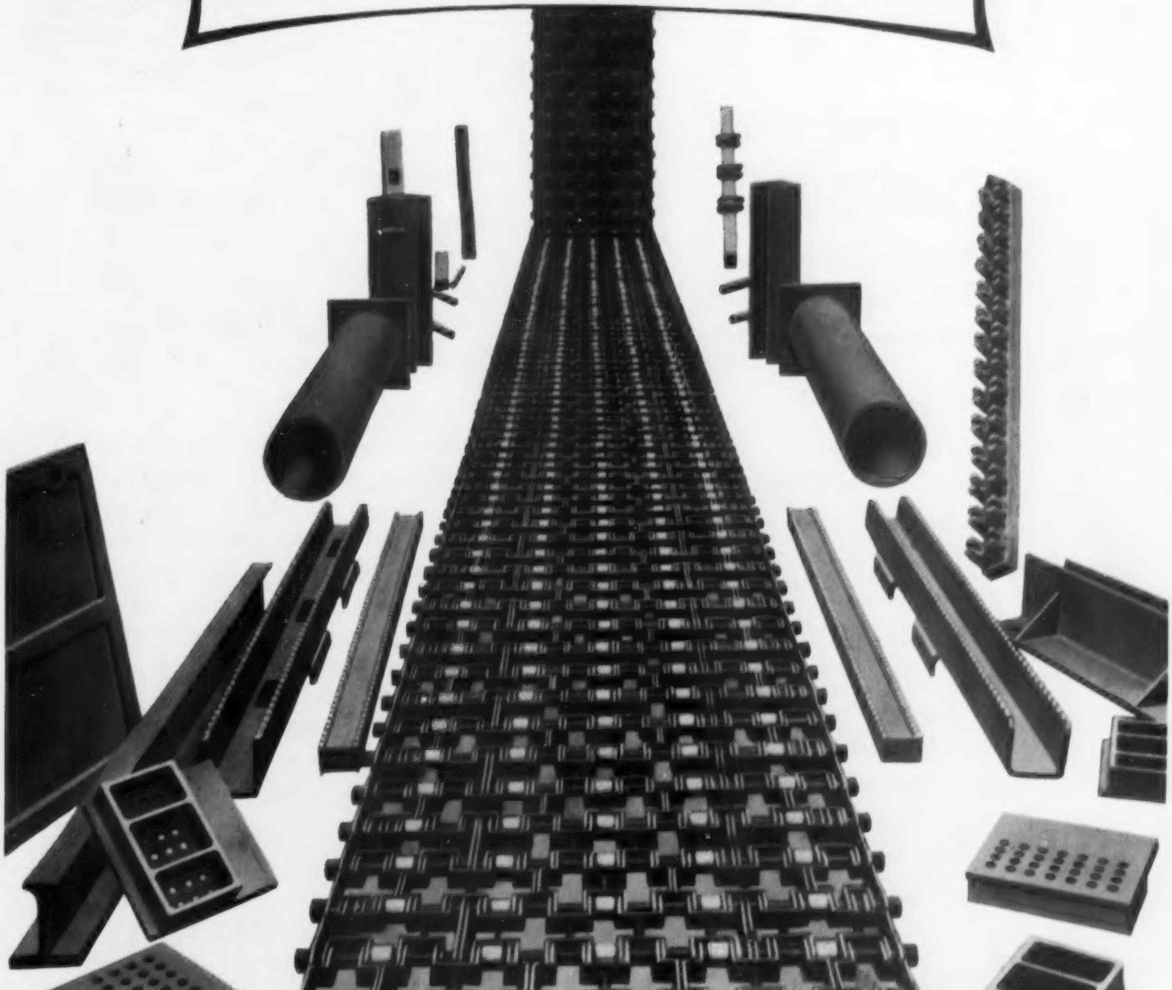

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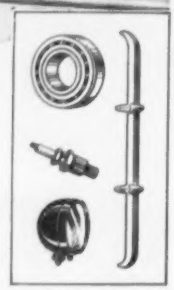

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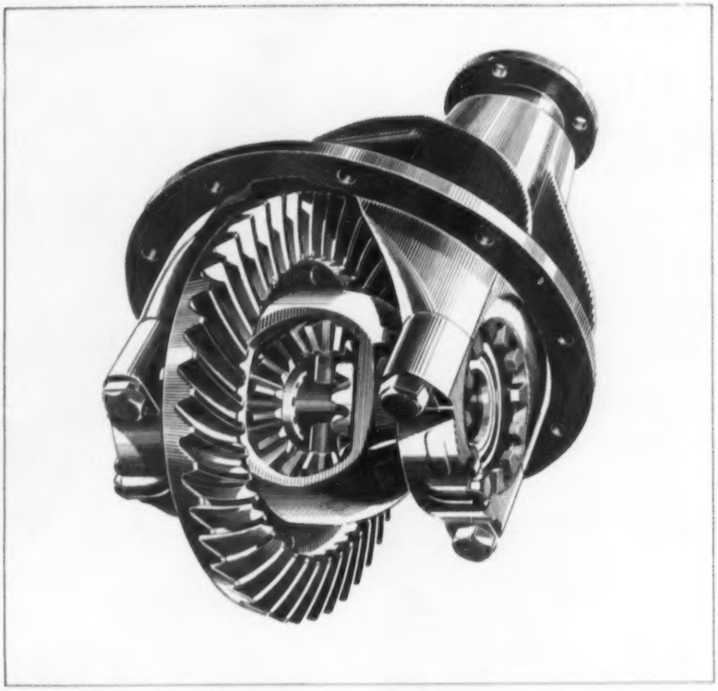

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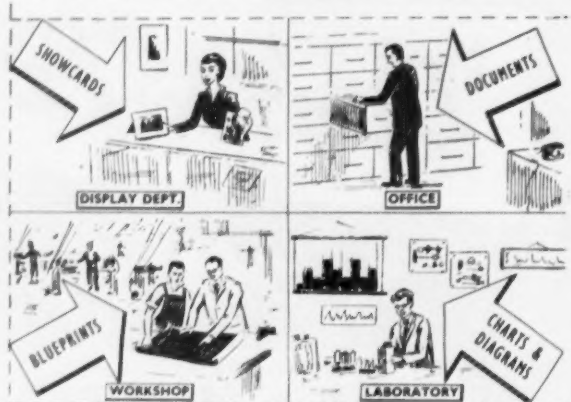

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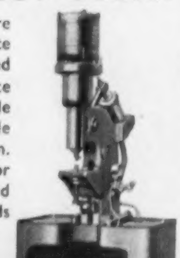

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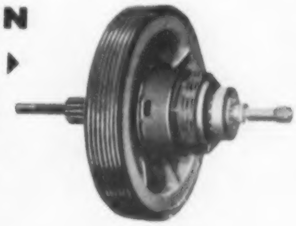

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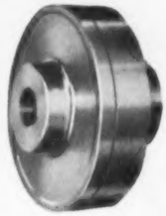

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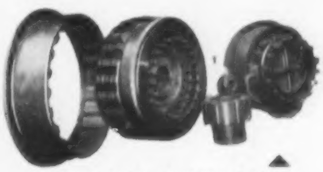

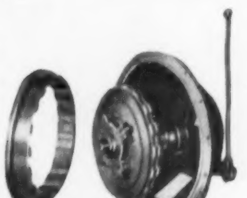

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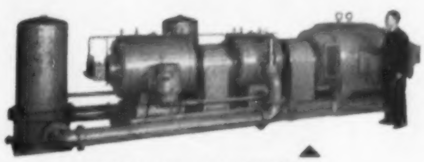

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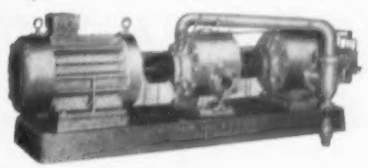

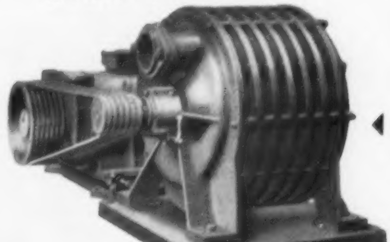

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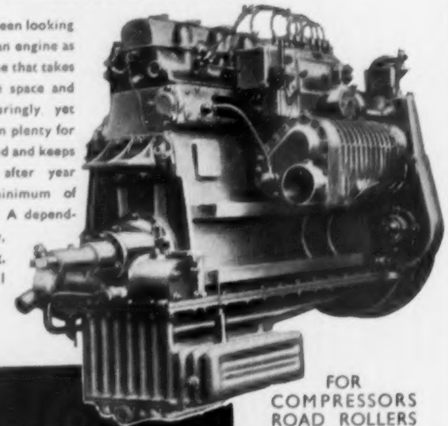

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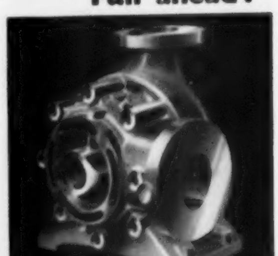

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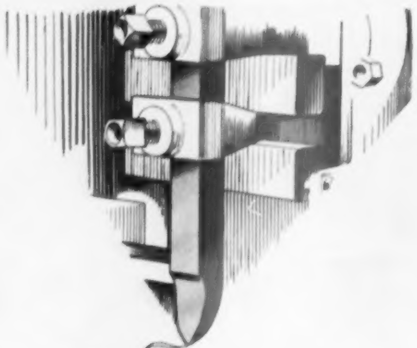

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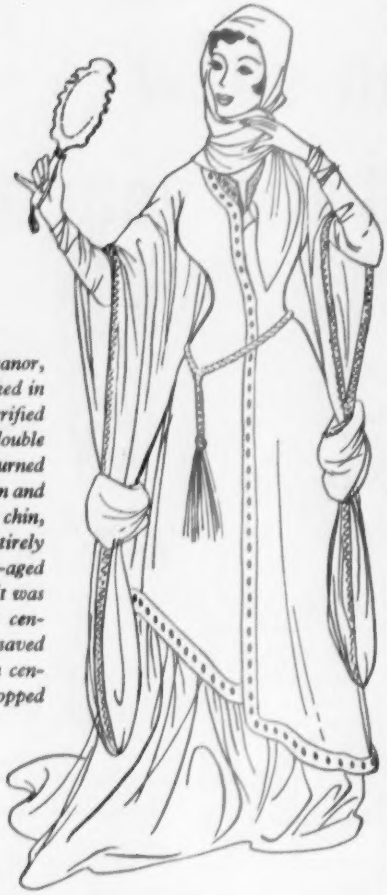

It all began when Eleanor, wife of Henry II, looked in a mirror and was horrified to find she had a double chin! Hastily, she turned her wimple upside down and wore it under her chin, thereby starting an entirely new fashion for middle-aged ladies. From then on it was all the rage. Twelfth century women found it saved face-lifts and Twelfth century men found it stopped their wives talking!

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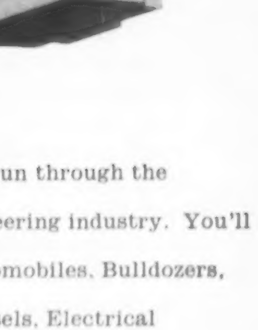

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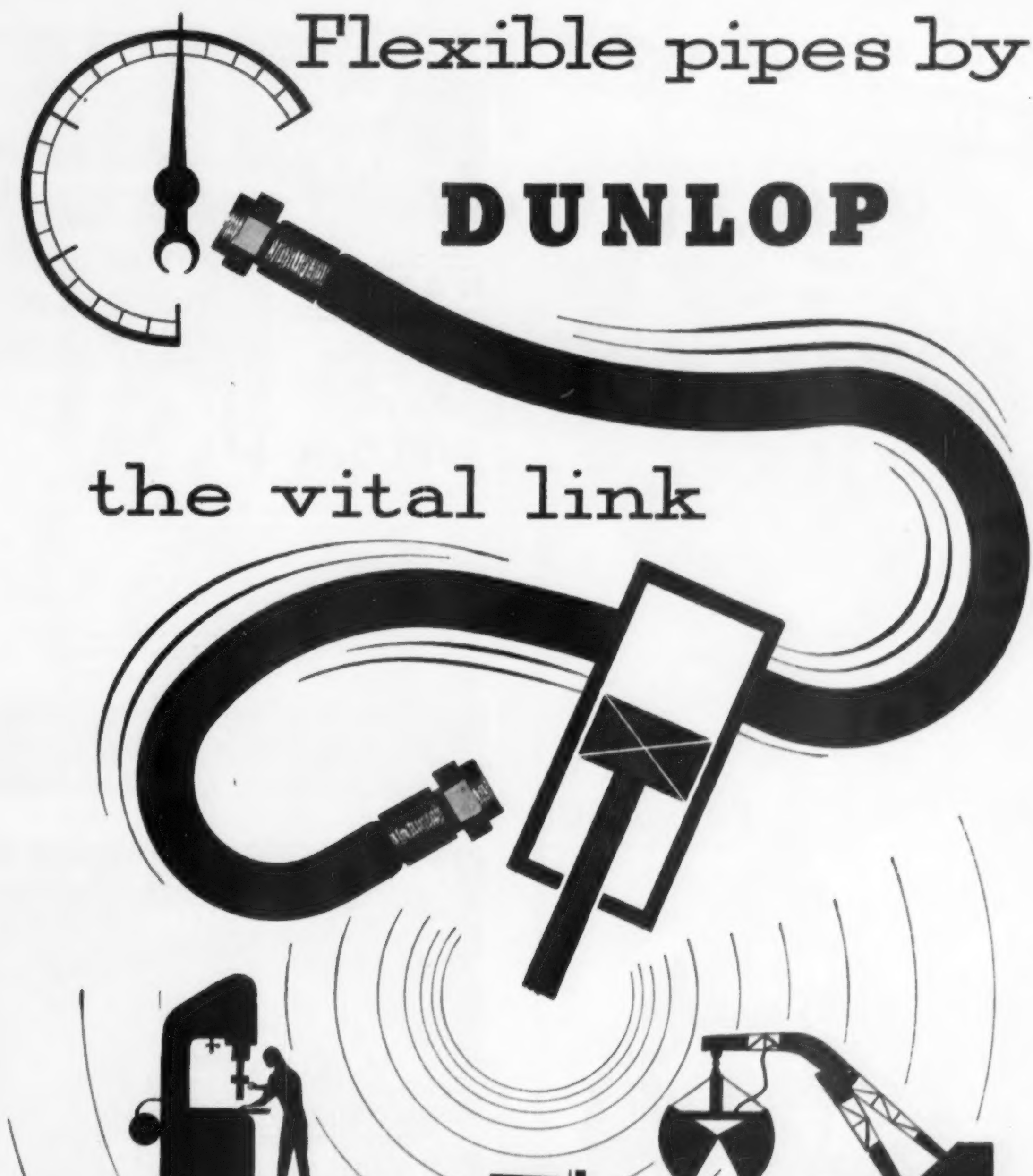
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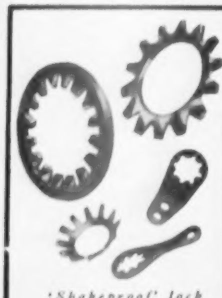

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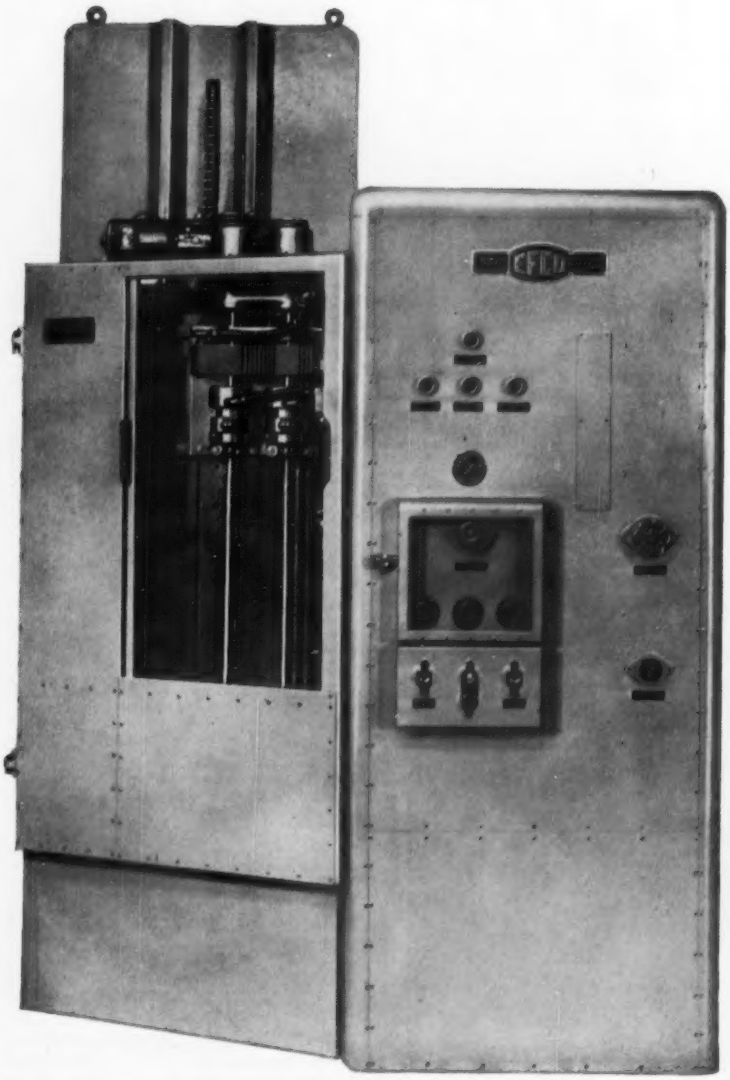

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FURNACE by Incandescent Heat for sale. Double end gas heated with motor-driven (3-phase) chain conveyor through heat chamber. Chamber 91 in. long × 23½ in. wide × 11½ in. high at crown. Weight about 6 tons. Photo, F. J. Edwards Ltd., 41 Water Street, Birmingham, 3, or 359 Euston Road, London, N.W.1. [5162

OVERHEAD Chain Monorail by the Coventry Construction & Engineering Co. Ltd. for sale. For transporting containers with handles, or similar articles. Motor drive 400/3/50. Monorail is carried by tubular steel supports. Hollow carrier brackets connected by endless link chain 15 in. centres; 7-direction change wheels, 24 in. dia. Total length of Monorail 400 ft. Full details from F. J. Edwards Ltd., 359 Euston Road, London, N.W.1, Euston 4681, or 41 Water Street, Birmingham, 3, Central 7606. [5163

BALLARD Drying Oven for sale, gas heated, with belt conveyor. Approximate size of oven, 40 ft. long × 12 ft. wide × 4 ft. high. Excellent condition. View in S. Wales. Full details, F. J. Edwards Ltd., 359 Euston Road, London, N.W.1, Euston 4681, and from 41 Water Street, Birmingham, 3, Central 7606. [5164

PATENTS

THE Proprietor of British Patent No. 660670, entitled "Improvements in Differential Devices for Motor Vehicles," offers same for licence or otherwise to ensure its practical working in Great Britain. Enquiries to Singer, Stern & Carlberg, Chrysler Building, New York 17, N.Y., U.S.A. [5144

THE Proprietor of British Patent No. 719486, being a brake for private and commercial vehicles entitled "Concentric Cam," offers same for licence or outright sale, to ensure the practical working of same in Great Britain. Enquire, Re-lined Brake Drums Ltd., 76 Stoke Newington High Street, N.16. [5037

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The engagement of persons answering these advertisements must be made through the local office of the Ministry of Labour and National Service, etc., if the applicant is a man aged 18-64 or a woman aged 18-59 inclusive, unless he or she or the employer is excepted from the provisions of The Notification of Vacancies Order 1952.

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HIGH speed diesel engines.

AIRCRAFT gas turbines or automobile transmission system.

APPLICATIONS with full details of qualifications and past experience to Reference "634," Technical Personnel Manager, Box 0313, c/o Automobile Engineer. [5152

PASSENGER Car Automatic Torque Converter Transmission Designer required to take charge of the development of a new British automatic transmission.

APPLICANT must be thoroughly versed in the subject, and cognizant of American technique. Promising opening for keen, qualified Designer. Apply Box 0640, c/o Automobile Engineer. [5159

GIRLING LIMITED, Tyseley, Birmingham, require Draughtsmen in their Development Drawing Office for work on hydraulic control systems for road and rail vehicles. Previous experience in these fields would be an asset for senior men, but seniors and juniors with general experience will be welcomed. Apply by letter to Personnel Manager, Girling Ltd., Kings Road, Tyseley, Birmingham, 11. [5160

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MEN with at least Higher National Certificate, aged from 35 to 45 and keen to make their mark have the basic requirements. They must be prepared to learn new techniques fast. In return they will find us top quality employers. From pay to pension, Ford is in the first flight. Why not forge ahead with Ford? The address is Salaried Personnel Department, Ford Motor Company Limited, Dagenham, Essex. Please quote reference QCA/2 [5166

CAPABLE Designer-Draughtsman (Mechanical) wanted for work on Wire and Tube Drawing Machines, etc. Experience in this class of work preferable but not essential. Commencing salary £900 p.a. Good general conditions—pension scheme. Assistance given with housing and removal expenses. Reply, giving full details of age and experience to Box 0796, c/o Automobile Engineer. [5161

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SHELL-MEX AND B.P. LIMITED have a vacancy for a man of personality to act as a Junior Automobile Engineer. Applicants must have Higher National Certificate as a minimum qualification. Preference will be given to those who have served an apprenticeship with a heavy vehicle manufacturer. Candidates should normally be between twenty-five to thirty years of age, and be prepared to work in any part of the United Kingdom. Initial probationary training period; starting salary commensurate with age, qualifications and experience. Excellent pension scheme. Ample scope for promotion throughout the organization for a keen man of ability and intelligence. Apply, giving full details of education, qualifications, age and experience to: Staff Manager (Ref D/67), Shell-Mex and B.P. Limited, Shell-Mex House, London, W.C.2. [5168

GARAGE Supervisor is required by the Mobil Oil Company Limited at their Coryton Refinery, Essex. Applicants must possess at least a National Certificate or City and Guilds Diploma in Automobile Engineering, or equivalent technical qualifications. Applicants must now hold a supervisory position operating and maintaining a large private or municipal garage, and have had practical experience of diesel and petrol engines, fuel injection equipment, auto electrical equipment and engine testing. The position requires a man who is able to work with little supervision. Modern housing accommodation is available in the nearby new town of Basildon. Conditions of employment include a Pension and Life Assurance Scheme, Sickness Benefit Plan, Sports and Social Club. Applications, giving full details of qualifications and experience, should be addressed to the Employee Relations Superintendent, Mobil Oil Company Limited, Coryton Refinery, Stanford-le-Hope, Essex. [5169

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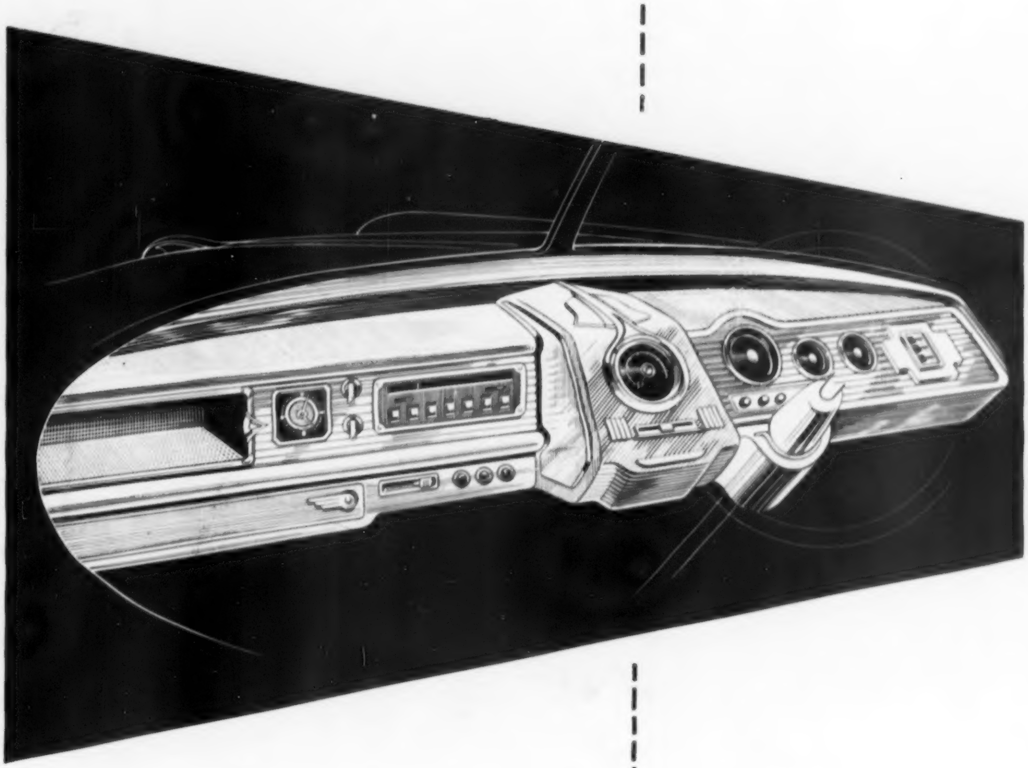
Cutting a Dash . . .



Or rather die casting a dash, for, by using MAZAK, this is the ideal way to make a car facia, quickly and economically, as a strong, rigid unit, exact as to size, readily assembled, and incorporating mountings for all the instruments. And as to appearance, an attractive overall design, combined with the high finish made possible by the firm smooth MAZAK surface, lends the final touch of distinction to a worthy component which will indeed " cut a dash".

MAZAK

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APRIL 1956

plan with Birmal

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